Index

Academy Color Encoding System, 566–7
to display luminance, 237
to illumination characteristics, 42, 97, 193, 200
to surrounding areas, 193

2014 augmented documentation, 605

to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193

2014 augmented specifications, 609–15

to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193

2014 current post configurations, 616–23

to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193
a representative 2015 workflow, 616–23

to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193
a colour managed workflow, 620

to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193
a custom and practice workflow, 620–3

to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193

2015 a representative ACES 2014 configured system (See Fig 34.15), 624

2015 progress in adoption of system (See Section 34.1), 603

ACES colour space, 572–6

ACES primaries chromaticities, 572–3
to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193
digital encoding format, 445
to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193
primary specification description, 572–87
to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193
reference display, 583–5
to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193
Reference Input Capture Device (RICD), 576–8
to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193
system workflow, 569–72

Academy of Motion Picture Arts and Sciences, 565

Accommodation time to accommodate, 42

Acronyms, 560

Acuity of the Eye, 171

Adaptation chromatic, 97, 98
to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193
range, 11

Adobe Bridge, 523

Adobe Lightroom, 523

Adobe Photoshop, 447, 449

Camera RAW, 201, 408, 447, 449–50
to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193
colour management settings, 510–21.

Adobe Bridge
Photoshop settings

printer driver, 449
to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193
proofing, 476

to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193
working colour space, 453

ADX, 567

Alychne, 65, 67

American Society of Cinematographers, 565, 588

AMOLED Displays, 170

Angle Subtended by the Display at the Eye, 172

Appraising the Rendered Image
in photography, 409
to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193
colour proofing, 476
to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193
comparison of prints and transparencies, 470–1

to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193
monitor display, 409
to display luminance, 237

to illumination characteristics, 42, 97, 193, 200

to surrounding areas, 193
summary of rationalised viewing conditions (See Section 26.7), 479

viewing conditions ISO 3664, 476

© 2016 John Wiley & Sons, Ltd. Published 2016 by John Wiley & Sons, Ltd.
Companion Website: www.wiley.com/go/toomscolour
## Index

- **Appraising the Rendered Image (Continued)**
  - in television, 391
    - ITU Rec 500, 395
  - standard displays, 396
  - viewing distance, 477
  - in various environmental lighting, 186

- **Artefacts**
  - masking, 252

- **Aspect Ratio**, 171

- **Barten, P.G.J.**, 234

- **Bayer Mosaic**, 406, 462

- **BBC**, 304
  - colour test transmissions, 308

- **Black**
  - black level, 229, 252, 264, 265, 268, 303, 318, 320, 347, 366, 370, 397
  - digital signal black, 265
  - image black, 264
    - level, 265
    - perceived black level, 264, 265
    - perceptual black, 264, 265, 269
g  - determining the level, 265
  - photographic black, 366

- **Black Point Compensation**, 521

- **Bradford Transform**, 103, 645

- **Brightness**. See **Colour Terminology**

- **Camera**, 162–5

- **Camera Lenses**, 165

- **Camera Signals**
  - before and after matrixing to a smaller gamut, 204
  - clipping, 205
  - effect of inability to produce negative signals, 209, 211
g  - gamma corrected, 277
  - negative signals, 205, 209

- **Camera Spectral Sensitivities**, 163
  - a colorimetical ideal set, 216
    - CIE XYZ primaries, 216–7
      - derived from the $u',v'$ diagram, 217–9
g  - general considerations, 221–2
    - ideal set 1, 222
    - ideal set 2, 221

- **ACES RICD**, 576–8

- Adobe RGB primaries idealised, 407
  - characteristics, 176
  - characteristics for a set of ideal display primaries, 180
  - corresponding to colour matching functions, 175, 177
g  - derivation of, 352, 683
  - EBU TLCI “Standard”, 339
    - idealised, 176
  - idealised NTSC, EBU & SMPTE RP145 characteristics, 312, 314
  - in terms of $x(\lambda), y(\lambda), z(\lambda)$, 181
  - native, 206
  - negative lobes, 210, 216
  - positive lobes, 216
  - sRGB primaries idealised, 278

- **Candela**
  - definition, 636
  - display screen, 169
  - relationship to lux, 12

- **Cathode Ray Tube**, 115, 225

- **CCIR**, 304

- **Chroma**. See **Colour Terminology**

- **Chromatic Adaptation**. See **Adaptation**

- **Chromaticity**, 16, 17. See **Colour Terminology**

- **Chromaticity Coordinates**
  - always positive, 62
  - CIE 1931 Standard Observer Primaries, 62
  - CIE ‘D’ illuminants, 99
  - Wright Primaries, 48

- **Chromaticity Diagrams**, 53–55
  - characteristics, 55–57
  - CIE
    - 1931 Standard Observer, 62
    - 1931 $x,y$ Chromaticity diagram, 64
    - 1960 Uniform Chromaticity Diagram, 73
    - 1976 Uniform Chromaticity Scale Diagram, 75, 76
  - comparison of $x,y$ and $u',v'$ diagrams, 76
  - $u',v'$ JNDs, 75
  - $x,y$ JNDs, 75
  - $x,y$ to $u',v'$ relationship, 73
g  - deriving chromaticity diagrams, 53–55
Index

plotting colours, 57–59
Wright Chromaticity Diagram, 63
Chromaticity Gamut
camera gamut, 205
chromaticity errors of unmatched gamuts, 208
chromaticity errors transforming to a smaller gamut, 208

cinematographic
ACES AP0, 611
ACES AP1, 627
comparison of ACES AP1 and Rec 2020, 628
DCDM, 579
DCDM reference projector SMPTE RP 431-2, 583
colours inside and outside of gamut, 178, 180
comparison of gamut of two printers, 312
display
sRGB, Adobe RGB, Rec 2020, 628
example transform gamuts, 206
ideal set of camera primaries 1, 332
ideal set of camera primaries 2, 332
ideal set of display primaries, 177, 180
of set of five printing inks, 425
of set of three representative printing inks, 426
of system primaries, 177, 181, 207, 221
out of gamut colour samples, 136
photographic
capture
sRGB, Adobe RGB, Adobe Wide Gamut, hypothetical RAW, 440
computer
ProPhot RGB/ROMM RGB, ColorMatch RGB, 450
printer
fundamentals, 416–22
representative printers, 425–30
Pointer gamut of real surface colours, 210
Rec 2020, 327, 382
Rec 709, 384
SMPTES 431-2, 599
transform, 661
Chromatic Gamut Transforms, 661
deriving a matrix of transformation, 206, 661–65
moving successively between gamuts, 213
source gamut larger than display gamut, 209
source gamut smaller than display gamut, 206
specific matrix transforms
ACES AP0 to ACES AP1, 627
ACES AP0 to DCDM, 628
ACES AP0 to Rec 2020, 628
ACES AP0 to SMPTE RP 431, 628
ACES AP1 to ACES AP0, 627
ACES AP1 to Rec 2020, 627
ACES SP0 to Rec 709, 376
any gamut to any other gamut – Worksheet 12(a), 581
camera native to XYZ, 221
DCDM to Rec 2020, 601
DCDM to SMPTE RP 431-2 reference projector, 589
EBU to SMPTE RP 145, 310
‘Ideal 1’ camera to ‘Ideal’ display, 210
‘Ideal 1’ camera to sRGB, 222
‘Ideal’ display to Rec 709, 371
‘Ideal’ display to sRGB, 210
SMPTE RP 145 to EBU, 310
sRGB to AdobeRGB, 454
XYZ to ‘ideal’ display, 181

CIE, 61
1931 Standard Colorimetric Observer, 62
CIE Photopic Spectral Luminous Efficiency Function, 634
CIECAM02, 16, 94
CIECAM97, 16
CIE-CAT102, 103
CIE-CAT97, 103
CIEXYZ values of colour matching functions, 490
colour appearance models, 16
description of, 61
system of colour measurement, 61–95
colour matching functions, 61
the transform process, 67
Cinematographic System, 566–568
  archiving, 564
  introduction of digital to post, 565
  post, 560, 563, 564, 588, 615–628
  production, 563, 564, 588, 603, 604, 606, 615–628
  specification requirements (See Section 31.3), 566
  specifications (See Section 31.4), 566
  traditional roots (See Figure 31.1), 563
ColorChecker Chart. See Macbeth
  ColorChecker Chart
Colorimeter, 47
Colorimetry, 46–55
  in reproduction, 132
Colour
  brown, 34
  equal energy white, 76
  grey, 35
  neutral, 20
  stimuli, 20
  white, 34. See also White
Colour Blindness, 5
Colour Components. See Colour Signals or Colour Components
Colour Decision List, 560, 588
Colour Difference
  caused by contrast law changes (See Table 13.1), 260
CIEDE2000
  Colour Difference Equation, 94
  TLCI, 299
colour errors of unmatched chromaticity gamuts, 209
colour errors transforming to a smaller gamut, 213
measuring, 94
of illuminants, 134
system errors, 338, 349
Colour Gamut. See Colour Spaces
Colour Management
  in cinematography
    colour managed workflow, 620
    in production and post (See Section 32.10), 587
    matching reference and cinema displays, 579
  in photography
    an exercise in matching scene, display and print, 496
    check list for good results (See Section 29.8), 550
    critical areas of application, 404
generating profiles, 551–557
  ICC profile system, 410
  in equipment and scene capture, 495–595
  in the desktop workflow, 507–550
  in the infrastructure, 483
  operating system settings, 407
    Windows photo viewer, 523
  overview, 405
  Photoshop settings, 510–521
    appraising match of the display and print, 548
    appraising match of the scene and display, 543
    appraising match of the scene and the print, 549
    black point compensation, 521
    Color Settings Panel, 511
    for a hard proof print, 540
    image adjustments, 508
    managing profiles, 508
    opening files in Photoshop, 526
    previewing files, 522
    print parameters, 543
    RAW files, 524
    rendering intent, 521
    viewing the soft proof, 539
  print media, 490
  reasons for poor results, 503
  requirement for a new profile, 551
  requirements of an infrastructure strategy, 485
  viewing station, 501
  in television, 299
    accommodating scene illumination, 299
environment for picture appraisal and adjustment, 396
gamma, 318
picture matching
  control room environment, 390
  critical viewing distance, 393
display – luminance of surrounding area, 390
flat panel displays, 397
monitors, 391, 392, 393
viewing distance, 393
the importance of equipment line-up, 396
variables managed, 404
picture matching
  field of view, 394
  grey scales, 405
Colour Matching Equations, 68
Colour Matching Functions
  \( \bar{x}(\lambda), \bar{y}(\lambda), \bar{z}(\lambda) \), 68, 181, 644
derivation of, 312–314
match to camera spectral sensitivities, 312
measuring colour
  CIE \( \bar{x}(\lambda), \bar{y}(\lambda), \bar{z}(\lambda) \) CMFs, 68
  Wright \( \bar{r}(\lambda), \bar{g}(\lambda), \bar{b}(\lambda) \) CMFs, 69
relationship to camera spectral sensitivities, 132
Standard Colorimetric Observer, 62
Colour Naming, 1
differentiation, 214
incorrect, 4
problems with, 3
spectrum colours, 6
Colour Reproduction
  appraising the reproduced image, 131
camera technology, 131–132
colorimetry in colour reproduction, 175
  concepts, 131
current limitations in television, 359
display devices technology, 366–369
ideal colorimetric system, 377
potential for improvement in television, 386
signal flow, 299
system specification, 289
deriving, 289
  output referred system, 589
  representative specification, 291
scene referred system, 289
Colour Signals or Colour Components, 271, 449
  chrominance signals, 279
colour difference signals, 279
  ideal system, 360
exceptional signals, 375
  UHDTV, 360
HDTV, 360
luma signal, 277
luminance signal, 276
Review of component formats, 457
signal level excursions outside of Rec 709 limits (See Section 20.3.2), 373
signal levels of optimal colours, 374
UHDTV, 360
YCbCr format, 458
Colour Solid. See Colour Space
Colour Space
  CIE 1976 \( L^*u^*v^* \), 79–80, 135
  limitations (See Section 4.9), 91
  reconciling location of Munsell and optimal colours, 90
  shape, 84–88
  CIE \( L^*a^*b^* \), 461, 489
  CIE \( U^*V^*W^* \), 135
  CIE XYZ, 72, 363
  three dimensions, 34
Colour Spaces
  extending, 320
  in cinematography
    ACES, 570
    ACEScc, 605
    ACESproxy, 567
    DCDM, 579–584
  Output Colour Encoding Space, 580
  SMPTE RP 431-2, 583
in displays, 366
in photography, 407
  Adobe RGB (1998), 444
  Adobe Wide Gamut, 446
  CIE LAB – PCSLAB, 489
  CIE XYZ – PCSXYZ, 489
  ColorMatch RGB, 452
  future extended, 454
  hypothetical RAW, 448
  ICC working colour space, 488
  merits of \( L^*a^*b^* \) colour space, 453
  Profile Connection Space, 452, 489
  proof PCS, 492
  ProPhoto RGB/ROMM RGB, 450
  sRGB, 440
  working colour spaces, 453
Colour Space (*Continued*)

<table>
<thead>
<tr>
<th>in television</th>
</tr>
</thead>
<tbody>
<tr>
<td>historic, NTSC, EBU, SMPTE RP145, 312</td>
</tr>
<tr>
<td>ITU Rec 2020, 382</td>
</tr>
<tr>
<td>ITU Rec 709, 343</td>
</tr>
<tr>
<td>of primary colours, 19</td>
</tr>
</tbody>
</table>

Colour Temperature, 111

| matching daylight and tungsten illumination, 129 |
| Sun, 144 |

Colour Terminology, 37

| chroma, 37 |
| Munsell, 38 |
| purity, 37 |
| value |
| Munsell, 39 |

Colour Transforms. *See also* Matrixing Colour Signals

Colour Transforms

| colorimetric |
| Bradford transform, 103 |
| chromatic adaptation transforms, 97 |
| CIE CAT97, 103 |
| CIE XYZ to CIE Uniform Chromaticity, 72 |
| CIE XYZ to L'\textcolor{red}{u}^*\textcolor{red}{v}^*, 76 |
| von Kries transform, 102 |

reproduction

| ACES input device transform, 578 |
| ACES output device transforms, 580, 585 |
| colorimetric processing, 203 |
| in colour management, 484–90 |
| Reference Rendering Transform, 583 |
| RGB to u', v', 200 |
| system white, 193 |

Colours

| categorising, 38 |
| negative, 64 |
| neutral, 20 |
| number of perceivable colours, 88 |
| out of gamut, 200 |
| realisable, 64 |
| standard, 16 |
| test colours, 134 |
| CIE CRI, 135 |
| CIE CRI extended range, 142 |

Cones, 10

| beta, gamma and rho responses, 22 |
| hypothetical responses, 20 |
| metamerism, 98 |
| responses, 15, 62 |

Constant Luminance System. *See* Encoding Colour Signals

Contrast Law

| colour changes, 226 |
| definition, 227 |
| matching to the viewing environment, 257 system, 225 |

Contrast Range

| ACES contrast range, 572 |
| contrast ranges, 229 |
| display, 168, 230, 231 |
| displayed and perceived, 187 |
| extent overall, 37 |
| eye, 186, 225 |
| spatial dynamic, 263 |
| spatial static, 232 |
| graph of characteristic, 239 |
| high dynamic range (HDR), 368 |
| ideal system, 371 |
| in the cinema, 592 |
| perceived, 237 |
| currently in use, 370 |
| scene, 229 |
| sequential or inter-frame, 231, 263 |
| simultaneous or intra-frame, 231 |
| threshold of perceptibility, 233 |

Correlated Colour Temperature, 113, 134

| HMI lamps, 152 |
| xenon lamps, 151 |

CRI, 134

*Davies, E.R.*, 414

Daylight. *See* Illuminants

Demosaicing, 457, 462

Dichroic Filter, 195, 334

Digital Cinema Distribution Master, 586

Digital Cinema Initiatives, 589

| absolute or relative colorimetric encoding, 597 |
| DCDM interfaces, 599 |
| Digital Cinema Package, 601, 604 |
Index

encoding equations, 596
encoding format requirements, 590
image structure and operational levels, 590
Digital Coding, 253
DCDM, 599
perceptibility of quantisation level, 254, 255
Digital Contouring, 253, 574
Digital Motion Picture Camera, 564
Digital Negative Format DNG. See File Formats
Digital Source Master, 569, 589
Discrete Cosine Transform (DCT), 457
Display Devices, 165–71
ACES reference display, 580
Cathode Ray Tube, 225
DLP displays, 169
laser display, 170
LED displays, 169, 170
light generation, 165
liquid crystal display, 166
plasma displays, 170
DLP Displays, 169
Dominant Wavelength. See Colour Terminology
EBU, 304, 308
Recommendation R137 – Television Lighting Consistency Index 2012, 332
Tech 3353 – Development of a “Standard” Television Camera Model, 332, 334
Tech 3354 – Comparison of CIE Colour Metrics for TLCI-2012, 337
Tech 3355 – Method for the Assessment of the Colorimetric Properties of Luminaires, 332, 338
Efficacy, 150, 151, 152, 157
Electromagnetic Radiation, 106
Electromagnetic Spectrum, 8, 114, 631
Electro-Opto Transfer Function (EOTF), 190
CRT, 225
definition, 227
emulation in flat panel displays, 239
linear, 251
mismatch between Rec 709 and Rec 1886, 357
Rec 1886, 346–47
standardisation, 227
use in historic analogue systems, 318
EMI, 307
Encoding Colour Signals, 272
colour difference signals, 278
chrominance signals, 279
exploiting chrominance acuity, 282
data rates, 283
vector diagram (See Figure 14.5), 280
luminance, 275
constant luminance system, 280, 368, 373
camera, 283
display, 284
Eureka system, 371
ideal configuration, 360
UHDTV, 383, 387
deriving the luminance signal, 276, 362
luminance and luma signals, 277
non-constant luminance system, 285
camera, 286
display, 286
distortions, 288
multiplexing, 271
NTSC, 271
requirements, 272
compatibility with monochrome signals, 272
data reduction, 273
retaining colour balance, 272
retaining colour balance, 275
EOCF, 468
Equal Energy White, 113
Eureka System. See Television Systems
Eye
acuity, 273
eye brain complex, 17
luminous efficiency function, 9
Photopic Spectral Luminous Efficiency Function. See Photopic
receptors, 14
standard response concerns, 10, 17
FCC, 307
Fechner Weber, 13
law, 233, 399
<table>
<thead>
<tr>
<th>Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>File Formats, 459</td>
</tr>
<tr>
<td>DNG, 462</td>
</tr>
<tr>
<td>Exchangeable Image File Format (Exif), 462</td>
</tr>
<tr>
<td>JFIF, 465</td>
</tr>
<tr>
<td>JPEG, 465</td>
</tr>
<tr>
<td>JPEG Exif, 465</td>
</tr>
<tr>
<td>PNG, 465</td>
</tr>
<tr>
<td>summary of characteristics of file formats, 465</td>
</tr>
<tr>
<td>TIFF, 460</td>
</tr>
<tr>
<td>TIFF-EP, 462</td>
</tr>
<tr>
<td>Flare, 230</td>
</tr>
<tr>
<td>Floating Point Format Digital Coding, 576</td>
</tr>
<tr>
<td>Fogra, 456</td>
</tr>
<tr>
<td>Foveon, 406</td>
</tr>
<tr>
<td>Gamma, 227</td>
</tr>
<tr>
<td>gamma correction, 238–251</td>
</tr>
<tr>
<td>characteristic, 240</td>
</tr>
<tr>
<td>combining linear and power law characteristics, 244</td>
</tr>
<tr>
<td>CRT, 239</td>
</tr>
<tr>
<td>deriving the gamma correction formula, 667–672</td>
</tr>
<tr>
<td>determining location in the signal path, 252–253</td>
</tr>
<tr>
<td>distortion of tonal range, 250</td>
</tr>
<tr>
<td>elimination of display gamma correction, 360</td>
</tr>
<tr>
<td>exceptional signals</td>
</tr>
<tr>
<td>IEC 61966, 380</td>
</tr>
<tr>
<td>Rec 1361, 377</td>
</tr>
<tr>
<td>gain, 241</td>
</tr>
<tr>
<td>gamma corrector, 228</td>
</tr>
<tr>
<td>isolate from perceptible uniform coding, 360</td>
</tr>
<tr>
<td>limiting the gain, 242</td>
</tr>
<tr>
<td>performance with CRT, 246</td>
</tr>
<tr>
<td>requirement for, 238</td>
</tr>
<tr>
<td>source noise visibility, 252</td>
</tr>
<tr>
<td>specifying parameters, 245</td>
</tr>
<tr>
<td>system gamma, 257, 347, 361</td>
</tr>
<tr>
<td>values, 227</td>
</tr>
<tr>
<td>Gamut Mapping, 213</td>
</tr>
<tr>
<td>choice of strategies, 215</td>
</tr>
<tr>
<td>mapped chromaticity errors, 213</td>
</tr>
<tr>
<td>Gas Discharge Spectra, 115</td>
</tr>
<tr>
<td>mercury, 115</td>
</tr>
<tr>
<td>sodium, 117</td>
</tr>
<tr>
<td>xenon, 118</td>
</tr>
<tr>
<td>Grading</td>
</tr>
<tr>
<td>in post, 563–564, 580, 628</td>
</tr>
<tr>
<td>in television, 301</td>
</tr>
<tr>
<td>post reference display, 580</td>
</tr>
<tr>
<td>Grassman’s Law, 32</td>
</tr>
<tr>
<td>application, 45</td>
</tr>
<tr>
<td>chromaticity diagram, 54</td>
</tr>
<tr>
<td>Grey Component Replacement, 429</td>
</tr>
<tr>
<td>Grey Scale Chart, 197</td>
</tr>
<tr>
<td>appearance, 267</td>
</tr>
<tr>
<td>appraisal, 268</td>
</tr>
<tr>
<td>as a means of checking all is well, 261</td>
</tr>
<tr>
<td>designing, 261</td>
</tr>
<tr>
<td>digital code values, 268</td>
</tr>
<tr>
<td>equally perceptible lightness steps, 261</td>
</tr>
<tr>
<td>exercise in matching scene, display and print, 499</td>
</tr>
<tr>
<td>matching code values to lightness values, 264</td>
</tr>
<tr>
<td>use in determining current perceived contrast range, 268</td>
</tr>
<tr>
<td>Guild, J., 46, 61</td>
</tr>
<tr>
<td>working primaries, 62</td>
</tr>
<tr>
<td>HDTV. See Television Systems</td>
</tr>
<tr>
<td>Hertz, Heinrich, 9</td>
</tr>
<tr>
<td>Hue</td>
</tr>
<tr>
<td>100 hues, 40</td>
</tr>
<tr>
<td>characterisation, 4</td>
</tr>
<tr>
<td>chromaticity diagram, 52</td>
</tr>
<tr>
<td>complementary, 38</td>
</tr>
<tr>
<td>cyan, 4, 6</td>
</tr>
<tr>
<td>Indigo, 7</td>
</tr>
<tr>
<td>Munsell, 39, 40</td>
</tr>
<tr>
<td>response of eye to spectral hues, 33</td>
</tr>
<tr>
<td>terminology, 37</td>
</tr>
<tr>
<td>unitary, 3</td>
</tr>
<tr>
<td>white, 5</td>
</tr>
<tr>
<td>Human Visual Modulation Threshold, 233, 234, 368, 574, 592</td>
</tr>
<tr>
<td>Hunt, R.W.G., 16, 75, 94, 102, 104, 145, 154, 257</td>
</tr>
<tr>
<td>Index</td>
</tr>
<tr>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>ICC</td>
</tr>
<tr>
<td>formation, 410, 487</td>
</tr>
<tr>
<td>ICC V4, 523</td>
</tr>
<tr>
<td>ICC.1-2010-12, 487</td>
</tr>
<tr>
<td>Profile Connection Space, 488</td>
</tr>
<tr>
<td>profile system of colour management, 488</td>
</tr>
<tr>
<td>the system in practice, 491–493</td>
</tr>
<tr>
<td>IEC, 300</td>
</tr>
<tr>
<td>IEC 61966-2-1, 206</td>
</tr>
<tr>
<td>IEC 61966-2-4, 375, 380</td>
</tr>
<tr>
<td>IEC61966, 380</td>
</tr>
<tr>
<td>Illuminance, 471</td>
</tr>
<tr>
<td>Illuminants, 133</td>
</tr>
<tr>
<td>CCT and chromaticity coordinates of defined reproduction illuminants</td>
</tr>
<tr>
<td>200</td>
</tr>
<tr>
<td>CIE ‘D’ illuminants, 146</td>
</tr>
<tr>
<td>CIE Illuminant SA, 148</td>
</tr>
<tr>
<td>ColorChecker chart under different illuminants, 202</td>
</tr>
<tr>
<td>colour errors using incorrect system illuminant, 201</td>
</tr>
<tr>
<td>D60, 573</td>
</tr>
<tr>
<td>daylight, 143</td>
</tr>
<tr>
<td>Sun, 144</td>
</tr>
<tr>
<td>Illumination</td>
</tr>
<tr>
<td>CIE daylight specifications, 147–148</td>
</tr>
<tr>
<td>colour rendering, 134</td>
</tr>
<tr>
<td>colour rendering indices, 134</td>
</tr>
<tr>
<td>CIE colour rendering index, 135–140</td>
</tr>
<tr>
<td>CIE CRI limitations, 139–140</td>
</tr>
<tr>
<td>EBU TLCl, 143, 339. See also Lighting</td>
</tr>
<tr>
<td>MCC index, 140–143</td>
</tr>
<tr>
<td>Effect on perception of colour, 42</td>
</tr>
<tr>
<td>efficiency, 143, 154</td>
</tr>
<tr>
<td>environmental, 230</td>
</tr>
<tr>
<td>historic studio lighting (See Section 17.2.5), 318</td>
</tr>
<tr>
<td>ideal, 42</td>
</tr>
<tr>
<td>overview, 133</td>
</tr>
<tr>
<td>range of outdoors, 10</td>
</tr>
<tr>
<td>relationship to luminance, 12</td>
</tr>
<tr>
<td>Image Interchange Framework, 566, 567, 569, 580, 583, 599</td>
</tr>
<tr>
<td>configuration, 570</td>
</tr>
<tr>
<td>for viewing graded signals, 579</td>
</tr>
<tr>
<td>Image Resolution, 171</td>
</tr>
<tr>
<td>compression technology, 275</td>
</tr>
<tr>
<td>‘K’ systems, 273</td>
</tr>
<tr>
<td>pixel and digital data per image, 273</td>
</tr>
<tr>
<td>relationship to geometry and structure, 273, 274</td>
</tr>
<tr>
<td>system specifications, 290, 310, 343, 371, 376, 566</td>
</tr>
<tr>
<td>Infrared, 8, 108, 109, 114, 119, 123, 144, 149</td>
</tr>
<tr>
<td>Intensity. See Colour Terminology</td>
</tr>
<tr>
<td>Intents. See Rendering Intents</td>
</tr>
<tr>
<td>Ionised, 170</td>
</tr>
<tr>
<td>ISO, 300</td>
</tr>
<tr>
<td>ISO 12234, 462</td>
</tr>
<tr>
<td>ISO 12608, 394, 395</td>
</tr>
<tr>
<td>ISO 12640-3, 491</td>
</tr>
<tr>
<td>ISO 12646, 469, 474, 476, 480, 495</td>
</tr>
<tr>
<td>ISO 13655-2009, 489</td>
</tr>
<tr>
<td>ISO 15076-1 2005, 487</td>
</tr>
<tr>
<td>ISO 3664-2009, 468, 469</td>
</tr>
<tr>
<td>ISO/IEC 10918.5, 465</td>
</tr>
<tr>
<td>ISO/IEC 15948-2004, 465</td>
</tr>
<tr>
<td>Speed Rating, 407</td>
</tr>
<tr>
<td>ITU, 227, 460</td>
</tr>
<tr>
<td>Recommendation ITU-R BT.1361, 375</td>
</tr>
<tr>
<td>Recommendation ITU-R BT.1886, 347</td>
</tr>
<tr>
<td>Recommendation ITU-R BT.2020, 382, 384</td>
</tr>
<tr>
<td>Recommendation ITU-R BT.2250, 381</td>
</tr>
<tr>
<td>Recommendation ITU-R BT.500-13, 394</td>
</tr>
<tr>
<td>Recommendation ITU-R BT.601, 305, 325, 465</td>
</tr>
<tr>
<td>Recommendation ITU-R BT.709, 329, 336</td>
</tr>
<tr>
<td>Recommendation ITU-R BT.709-5, 206</td>
</tr>
<tr>
<td>Recommendation ITU-R BT.814, 398</td>
</tr>
<tr>
<td>Report ITU-R BT. 2246, 383</td>
</tr>
<tr>
<td>Japan Electronics and Information Technology Association (JEITA), 462</td>
</tr>
<tr>
<td>Joint Photographic Experts Group (JPEG), 411, 457, 465</td>
</tr>
<tr>
<td>Joule, 106, 107, 114, 122</td>
</tr>
<tr>
<td>Just Noticeable Colour Differences (JNDs), 73, 209</td>
</tr>
</tbody>
</table>
Kelvin, 106, 122, 146, 649

Knight, Ray
- colour mixing, 32
- colour solid, 36
- hue circle, 40, 84
- photographic workflow, 406
- pigment mixes, 28
- unitary hues, 3–4

L*a*b* Colour Space. See Colour Space

L*a*b*. See Colour Space

Lamps, 148
- CIE FL range of lamps, 153
- cold cathode, 155
- CRI, 156
- electrical discharge lamps, 150
- fluorescent lamps, 153–155
- high pressure vapour discharge lamps, 152–153
- HMI lamps, 152
- incandescent based lamps, 148–149
- LED lamp performances, 157
- LED lamps, 155
- summary of characteristics, 158
- tungsten halogen lamps, 149
- xenon lamps, 150–152, 168

Laser, 124–126
- light amplification in lasers, 651–657

Laser Displays, 170–171

LED. See Light Emitting Diode

LED Displays, 170

Light
- black body chromaticity, 113
- black body radiation, 107, 110
- colour temperature, 111–113
- definition of, 6
- frequency, 8
- frequency wavelength relationship, 9
- generation
  - cathodoluminescence, 114–115
  - chemiluminescence, 113
  - electroluminescence solid state, 119
  - electroluminescent, 155
  - electroluminescence, 114
  - fluorescence, 126
  - fluorescent, 155
  - incandescence, 106
  - luminescence, 113–114
  - phosphorescence, 123
  - photon energy, 113
  - photons, 107
  - physics of generation, 105–106
  - Planckian locus, 112, 113
  - Planckian radiation, 106, 108
  - quantum levels, 113
  - standard method of measurement, 45–46
  - velocity, 107
  - wavelength, 46, 84

Light Emitting Diode LED, 119, 133, 331
- display contrast range, 231

Lighting, 331
- EBU Television Lighting Consistency
  - Index 2012
    - background, 331
    - comparison with CRI, 333
    - measuring the TLCI of luminaires, 338–339
    - methodology, 332
    - selecting a colour metric, 337–338
    - standard camera spectral sensitivities, 335
    - standard television system model, 333–334

Lightness, 13
- CIE L* characteristic, 76
- lightness axis, 35
- terminology, 37–38

Lindbloom, Bruce, 91, 93

Line Spectra, 62, 63, 114, 115

Look up Table (LUT), 425, 579, 586, 599

Luma signal. See Encoding Colour Signals

Lumen
- definition, 635
- in defining the lux, 10
- laser luminous output, 126
- luminous efficacy, 116

Luminaires, 105, 135, 148, 158

Luminance
- colour terminology, 37–38
- deriving the luminance of a surface, 638
- low luminance colours, 30
- luminance of light reflecting surfaces, 638–639

Luminescence, 113–114
Index

Luminosity Coefficients
definition, 62
sum to $V(\lambda)$, 62
values, 62
Luminosity Function, 9, 275, 276, 634, 635
Luminous Flux, 635–639
Luminous Intensity, 636
Lux, 10
definition, 636–637

MacAdam, D.L., 72, 85
Macbeth ColorChecker Chart, 141
an exercise in matching scene, display and print, 496–497
basis for measuring gamma colour differences, 259
consideration for measuring TLCI, 338–339
Rec 709 system performance evaluation, 349–350
use in measuring MCC rendering index, 140
use in measuring TLCI, 339

Maier, T.O., 233, 237, 568, 583, 589
Matrixing Colour Signals, 67, 102, 201, 204, 206. See also Chromaticity Gamut Transforms
camera to system primaries, 336
EBU TLCI standard matrix, 339
‘ideal display’ to sRGB display primaries, 210
sRGB to AdobeRGB display primaries, 207

Maxwell, James Clark, 9
Maxwell triangle, 19, 20, 33, 34
Mercury. See Gas Discharge Spectra
Mesopic. See Vision
Metermerism, 98–102
index of metermerism, 101–102
metamers, 101

Munsell, A.H., 38
Munsell and optimal colours, 90
Munsell Colour System, 39–42
Munsell colours plotted in Luv colour space, 91, 92

Murray, A., 414
Murray-Davies formula, 415

Nano metre, 9
Native Camera Characteristics, 365
Neugebauer
Neugebauer equations, 423–424

Newton, 5, 14
NHK, 304, 305, 324
NTSC. See Television Systems

Observers
1931 CIE Standard, 68
colour measurement, 45
measurement results, 51
Optimal Colours, 82, 85, 374
Opto-Electric Transfer Function (OETF)
camera image sensor, 227
vidicon, 239
Organic Light Emitting Diode OLED, 397, 480

PAL System. See Television Systems
Perceptible Uniform Coding
digital contouring perceptibility, 253–257
exponent perceptibility levels, 256, 257
independent of gamma correction, 360

Perception
artefacts, 233
compromise, 238
human visual modulation threshold
HVMT, 233
modulation levels, 234
of the rendered image, 469
Weber Barten relationship, 235
Weber’s law, 233, 234
Phosphors, 126–129
Photographic System, 405
photo viewer application, 407
technical standards, 409
JPEG, 411
requirement for, 409
sources of standards, 411
workflow overview, 405
camera processing, 407
computer processing, 407
file types, 407
matching colour spaces, 408
printer driver, 409
Photographic System (Continued)
  RAW file processing, 408
  soft proofing, 409

Photometric Units
  derivation, 631–639
  relationships, 639

Photometry, 636

Photopic. See Vision

Physiological, 632
  aspects of light, 634–635

Picture Matching. See Colour Management


Pixel, 162, 171
  minimum pixels to avoid limiting perceived resolution, 172

Planck, M, 106


Plasma Displays, 166, 170

PLUGE, 397–399

Pointer, M.R., 94, 102, 104, 145, 154, 179

Post (production), 189

Poynton, C., 107, 161, 254, 271, 277

Primaries – Colorimetric, 62
  CIE Standard Observer, 62, 66, 641, 642
  transform to XYZ primaries, 67

CIE XYZ
  criteria, 65
  deriving their chromaticities, 641–644
  location on r,g, chromaticity diagram, 66, 644
  luminance, 65

Wright, 61, 62

Primaries – Reproduction, 177
  ACES AP0, 613
  ACES AP1, 610–611
  Adobe RGB, 444
  Adobe Wide Gamut, 440–446
  an ideal set 1 of camera primaries, 218, 219
  an ideal set 2 of camera primaries, 220, 221

an ideal set of display primaries, 180, 181, 211, 363

choice of display primaries, 177–180

ColorMatch RGB, 450, 452

DCDM, 590

DCDM reference projector SMPTE RP 431-2, 599

Eureka system primaries, 371–373

example transformation primaries, 206

factors influencing the choice of the ideal display primaries set, 178

HDTV Rec 709, 341

imaginary, 362

matching system primaries to display primaries, 369

NTSC, EBU & SMPTE RP145, 309

ProPhoto RGB/ROMM RGB, 451

RAW – hypothetical, 448

sRGB, 440

subtractive primaries, 416

system primaries, 223
  XYZ primaries, 362

UHDTV Rec 2020, 382, 384, 582, 600

Primary Colours
  additive, 19
  block primaries, 25
  complementary primaries, 27
  general, 19
  imaginary, 64
  incorrect primaries, 4, 30
  reproduction primaries, 31
  subtractive primaries, 24, 414, 416, 420

Printing
  block dyes, 417
  dot gain, 415
  half tone prints, 414–415
  ink jet printers, 414
  paper
    comparison of gamut on matt and glossy paper, 437
    different whites, 435
    print head, 414, 415
    printer characterisation function, 423
    printer characteristics, 413–414
    printer inks, 422
    printer performance, 425
    printing concepts, 410–411
Index

Prism
    splitting light. See also Spectrum
Profile Connection Space, 452-453
    compared with ACES working colour space, 570
Profiles
    device dependent profiles, 487
    matching profiles in Photoshop, 517
    requirement for, 486
Proofing, 409, 491
    Adobe Photoshop, 409
    appraising the rendered image, 476
    display characteristics, 476
    producing a hard proof print, 543
    viewing the soft proof, 539
Purity. See Colour Terminology

Radiation Intensity, 633
RAW Files, 447, 458
Reference Displays
    ACES, 584
    AdobeRGB colour space, 446
    built in transfer function, 584
    flat panel, 628
    gamut clipping, 627
    low contrast image, 620
    output transform, 618
    post grading, 479, 625
    reference monitoring system, 628
    the requirement, 250
    working space, 620
Reference Rendering Transform, 583, 628
Rendering
    characteristics in post ‘custom and practice’ workflows, 620-622
    objective versus preferred rendition, 579
    rendering intents, 213, 489
RGB Gain Controls, 197
Roberts, A., 331
Rods, 10

Saturation
    chromaticity diagram, 53
    definition, 5, 34, 37
    terminology, 37
Science and Technology Council, 565, 569
Scotopic. See Vision

SECAM System. See Television Systems
Shade
    definition, 5, 38
    description, 38
Signal Path
    colour reproduction system, 190
    conceptual, 162
SMPTE, 233, 304
    AMPAS, 565
    SD digital sampling frequency, 324
    SMPTE RP 145, 310
    a world system primaries standard opportunity, 310
    SMPTE RP 431-2-2007, 567, 581, 589
    SMPTE ST 2065, 567
    SMPTE ST 2065-1,2,3,4, 605
    SMPTE ST 268-2003, 605
    SMPTE ST 428-1-2006, 567, 589
    SMPTE ST 431-1-2006, 567
television lighting index, 332
Sodium. See Gas Discharge Spectra
Spectral Emission
    semiconductor junctions, 123
    xenon, 150
Spectral Power Distribution
    1 W source of white light, 634
    CIE daylight ‘D’ illuminants, 145
daylight, 42, 143
    fluorescent lamps, 153
    HMI lamps, 152
    illuminants, 134
    LED lamps, 157
    of the scene, 175
Spectral Reflectance, 134
    CIE CRI test colour samples, 136
    ColorChecker primaries, 141
    Lucideon CERAM test tiles, 8
    metameric pairs, 101
    optimal colours, 85
    printing inks, 426
    extended CMY inks, 431
    red, blue and overlay primaries, 431
typical CMY inks, 426
Spectrum
    electromagnetic, 9
    locus, 63
    matching, 49
Spectrum (Continued)
    partial absorption, 7–8
    spectral power distribution (SPD), 20
    splitting, 5
Standard Colour Tiles
    chromaticity plots, 77
    Lucideon, 7
    reflectance characteristics, 8
Steradian, 632
Stiles, W.S., 14
SWOP, 456

Talbot, W.H.F., 414
Television Systems
    an ideal system, 360
    accommodating legacy services, 370
    camera and camera native spectral
    sensitivities, 365
    configuration, 360
    enabling factors, 360
    improvements, 360
    system and display primaries, 364
colour elements signal path, 303
diagram, 303
colour gamut
    Eureka system colour gamut, 372
    requirement to expand, 371
digital systems
    standard definition (SD), 325
    1K system, 325
    evolution of digital specifications, 324
    Recommendation ITU-R BT.601, 325
    colour parameters, 325
    colour signals digital format, 327
    gamma correction (OETF), 327
    standards conversion, 328
Eureka System Proposal, 371
HDTV
    colour difference signals, 347
    definition, 341
    emergence, 329
    gamma correction, 345
    idealised camera spectral sensitivities, 344
    matrix – Rec 709 from CIE, 343
performance evaluation, 348
    description of path elements, 348
    model veracity check conditions, 349
    non-specification lighting, 352
    performance appraisal, 357
    Rec 709 system gamma, 357
    signal path model, 348
    test colours, 349
    TLCI standard camera, 353
    worksheet mathematical model, 349
    Rec 1886, 357
    Rec 709 – principal parameters, 343
    Rec 709 observations, 343
    signal level limitations, 347
    system primaries, 343
    system specification, 341
historic analogue systems, 307–325
NTSC, 304
    early experience, 323
    establishment, 307
    NTSC, PAL & SECAM systems, 309–319
    encoding colour signals, 319–323
    gamma correction, 318
    ideal camera spectral sensitivities, 312
    matching camera responses to
    primaries, 314
    matching scene illumination to
    camera, 314
    system primaries and white point, 309
    studio lighting, 318
    specification and standard organisations, 304
    international organisations, 304
    national organisations, 304
UHDTV, 299, 360
    colour difference signals, 386
    exceptional signal levels, 376, 387
    gamma correction, 385
    informal appraisals, 388
    potential colour performance, 387–388
    system primaries, 384–385
    system specification, 360–361
Index

workflow, 324
camera channel, 301, 302
camera control unit, 301
home viewing, 303
vision control or picture control, 301
vision mixer, 302
Tint
definition, 37
description, 38
Tonal Range, 10, 440, 628
Tones
distortion of tonal range by gamma
correction, 253
tonal range of the eye, 13, 248
Transfer Characteristic. See Transfer
Function
Transfer Function
ACEScc, 627
ACESproxy, 625
Adobe RGB, 444
Adobe Wide Gamut colour space,
446–447
ColorMatch RGB, 452
CRT EOTF, 239
definition, 227
electro-opto transfer function EOTF, 227
gamma correction function, 242–245
mathematical relationship, 227
opto-electro transfer function OETF, 227
power law characteristic, 228–229
ProPhoto RGB/ROMM RGB, 450
Rec 1361, 377–380
specifying the source transfer
characteristic in a media system,
250
sRGB, 444
Transforms. See Colour Transforms
Trichromatic Units, 52
in producing chromaticity diagrams, 52
Tungsten Filament, 148, 318

UHDTV. See Television Systems
Ultraviolet, 8, 105, 108, 144, 170, 194, 311,
435, 632

V(λ) curve, 9, 62, 63
Value. See Colour Terminology

Viewing Conditions, 185
Adobe RGB colour space, 444, 468
environmental lighting, 186
colour temperature, 186
intensity of, 186
image angle of view, 187
in cinematography
review room environment, 585
in photography
ISO 3664-2009, 468
reference conditions, 468–470
summary of rationalised viewing
conditions, 476
influence on system design parameters,
188
reflections from display, 187
Viewing Distance, 171–173
Visible Spectrum, 4, 9, 46, 85, 88, 105,
106, 114–119, 149, 151, 153, 632,
634
Vision
mesopic, 10
photopic, 10
qualitative response, 10
quantitative response, 10
scotopic, 10
spatial response, 10
von Kries Transform, 102, 103
Waveform Monitor, 197, 198, 391, 396
Weber Barten Relationship, 232
Weber’s Law, 13
White
equal energy white (EEW), 70, 71, 76,
111, 147, 194, 314, 436, 593
image or peak white, 263
neutral white surface, 7
system reference white, 181, 193, 200,
201
DCDM, 593
for different media, 194, 573
mismatch between screen and print,
194, 496
plane of possible system white points,
594
system whites chromaticity plots, 594,
595
712

Index

White (Continued)
  white balance, 195
    automatic, 199
    colour errors with incorrect illuminant, 199
    criteria, 195
    manual, 196–199
  white surface, 196
Workflow. See Signal Path
Wright, W.D., 14
colour measurement, 46, 47, 61, 69
  just noticeable differences, 73
  working primaries, 62
Wright colorimeter, 48
Xenon. See Gas Discharge Spectra
X-Rite, 537, 552
Yule & Neilsen, 423