

Contents

Acknowledgements and Dedications	xxxiii
Foreword	xxxv
What This Book Is About	xxxv
What This Book Is <i>Not</i> About	xxxv
Why Should a Cinematographer Read This Book?	xxxv
Don't Bluff with Buzzwords, <i>Do Your Homework</i>	xxxv
As a Cinematographer, You Must Ultimately Serve Three Masters	xxxvii
Look Management	xxxvii
Where We Are Now	xxxviii
Chapter 1 Understanding Digital Theory	1
How Digital Cinema Cameras Work	1
Human Visual Response to Light	1
Sensing Light	2
Analog to Digital (A to D) Conversion	3
Encoding Luminance to Numerical Code Values	3
The Problem with Linear Encoding	3
The Just Noticeable Difference (JND) and Square Root Integral (SQRI)	4
Linear vs. Gamma/Logarithmic Encodings	5
Gamma γ A Video Power Function	5
ITU-R Recommendation BT.709	6
Logarithmic Encoding for Film: a History Lesson	6
10-Bit Log Cineon/DPX File Format	7
Cineon/DPX Encoding Ranges	7
Logarithmic Encoding for Digital Cinema	8
ARRI Log C	8
SONY S-Log	8
Display Referred vs. Scene Referred	9
Sampling Rate	10
Nyquist Shannon Sampling Theory	11

Color	12
Bayer Pattern CMOS Sensors	12
Color in the Digital Realm: What Are Pixels?	13
Color Bit Depth	13
Photosites Are NOT Pixels!	14
Color Bit Depth: How Many Crayons in the Box?	14
The Math of Color Sampling	14
The More Crayons, the Prettier the Pictures	15
ACES	15
Chapter 2 Camera Sensors, DeBayering, Sensitivity, and Noise	17
The Practical Differences between Film and Digital Sensors	17
Sensor Size Has an Effect on the Image We See	19
Bayer Pattern Sensors	19
RAW File Formats	21
De Bayering (De Mosaicing) RAW Bayer Pattern Images	21
De Bayering Algorithms	22
Nearest Neighbor	23
Bilinear Interpolation	23
Cubic Interpolation	23
High Quality Linear Interpolation	23
Smooth Hue Transition Interpolation	24
Pattern Recognition Interpolation	24
Adaptive Color Plane Interpolation	24
Resolution in Bayer Pattern Cameras	24
Converting RAW Images to RGB Images	24
Dead Pixel Removal	24
Noise Reduction	24
Linearization	25
Black Level Subtraction	25
Demosaic to RGB	25
Nearest Neighbor of Same Color	25
Averaging Same Colors	25
Using All Photosites	25
Lens Corrections	25
Cropping	25
Scaling	25

White Balance	25
Color Conversion	26
Color Enhancements	26
Toning Curve	26
Gamma Curve	26
Clip to Fewer Bits	26
Lossy Compression	26
Cinema DNG Format	26
On Board Image Processing	26
Optical Low Pass Filtering (OLPF)	27
Infrared (IR) Filtering	27
Rolling Shutter vs. Global Shutter	28
Skew	29
Wobble, Jello	29
Smear	29
Partial Exposure	30
Dark Frame Subtraction	30
Dynamic range and Exposure Latitude	31
How Much Picture Noise Is Acceptable in Digital Cinema?	32
Noise and Lower Dynamic Range Issues	33
Fixed Pattern Noise, Dark Noise, Readout Noise, Circuit Noise, and Photon Noise	34
Highlight Handling and Headroom	35
Fill Factor	36
Microlenses on Photosites	38
Sensitivity and ISO/ASA Rating	38
Sensitivity	39
ISO/ASA Rating/Exposure Index	39
Dual Native ISO Cameras	40
Chapter 3 Color	43
CIE XYZ 1931	43
The CIE 1931 Chromaticity Diagram	44
Color Temperature and White Balance	45
Color Space as It Relates to Cinematography	46
Color Gamut	48
Pointer's Gamut	48
SWOP CMYK Color Space	49

Rec 709 HDTV Color Space	49
DCI P3 Color Space	50
BT Rec 2020 UHD TV Color Space	50
AMPAS ACES AP0 Color Space	50
Camera Color Gamut	51
Gamuts Compared	51
Color Space Conversion or Transformation	52
Color Sampling and Subsampling	52
YCbCr and Y'CbCr Color	53
Color Has Traditionally Been Device Dependent	55
Scene Referred Color: ACES	56
Academy Color Encoding System (ACES)	56
ACES Components	56
ACES Benefits	57
For Cinematographers	57
For Visual Effects and Post-Production Facilities	57
For Content Owners	57
ACES Color Space Encoding	57
Viewing ACES	58
Preparation for Using ACES	60
Digital Cinema Color Spaces: P3, XYZ, X'Y'Z', and ACES	60
Chapter 4 The Color–Space Conundrum	63
The Beginnings of the Digital Intermediate	63
What Is Color Space?	63
Human Color Perception	66
Quantifying Human Color Perception: CIE 1931	68
Color Photography	69
Color in Cinematography	69
Color in Television	74
CIE 1976: CIE L*a*b*	77
The Birth of High Definition Video	77
Managing the Digital Revolution	78
The Birth of Digital Imaging	80
Hybrid Workflows: Film and Digital Coexist	82
Nyquist Sampling Theory	86
Modulation Transfer Function and Contrast Sensitivity Function	88