

R.W.G. Hunt  
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# MEASURING COLOUR

Fourth Edition

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# Measuring Colour

Fourth Edition

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# ***Prologue***

This is the story of Mister Chrome  
who started out to paint his home.  
The paint ran out when half way through  
so to the store he quickly flew  
to buy some more of matching hue,  
a delicate shade of egg-shell blue.  
But when he tried this latest batch,  
he found it simply didn't match.  
No wonder he was in a fix,  
for of the colours we can mix,  
the major shades and those between,  
ten million different can be seen.

You foolish man, said Missis Chrome,  
you should have taken from the home  
a sample of the colour done;  
you can't remember every one.  
Taking care that she had got  
a sample from the early pot,  
she went and bought her husband more  
of better colour from the store.  
Before she paid, she checked the shade,  
and found a perfect match it made.  
In triumph now she took it home,  
and gave it straight to Mister Chrome.  
He put it on without delay,  
and found the colour now okay.

But, after dark, in tungsten light,

they found the colour still not right.  
So to the store they both went now,  
with samples clear, and asked them how  
a paint that matched in daylight bright  
could fail to match in tungsten light.  
The man's reply to their complaint  
was that the pigments in the paint  
had been exchanged, since they had bought,  
for others of a different sort.  
To solve the problem on their wall,  
he gave them paint to do it all  
from just one batch of constant shade,  
and then at last success was made.

To compensate them for their trouble,  
the store sent to them curtains double.  
They hung them up with great delight;  
they matched in tungsten and daylight.  
A neighbour then did make a call  
and fixed his eye upon the wall;  
the paint, he said was all one colour,  
but clearly saw the curtains duller!

Though colours strange at times appear,  
the moral of this tale is clear:  
to understand just what we see,  
object, light, and eye, all three,  
must colour all our thinking through  
of chromic problems, old or new!

## ***About the Authors***



**Dr Robert W. G. Hunt** received his Ph.D and DSc from the University of London. He was a research scientist at the Kodak Research Laboratories, where he worked on factors affecting the quality of colour images, and devices for making reflection prints from both negative and positive images on film; he was finally Assistant Director of Research. Since 1982 he has worked as an independent colour consultant, and has taken a leading role in the development of colour appearance models. He has written over 100 papers on colour vision, colour reproduction, and colour measurement, and his other book, *The Reproduction of Colour*, is now in its sixth edition. He has been awarded the Newton Medal of the Colour Group (Great Britain) (1974), the Progress Medal of the Royal Photographic

Society (1984), the Judd-AIC Medal of the International Colour Association (1987), the Gold Medal of the Institute of Printing (1989), the Johann Gutenberg Prize of the Society for Information Display (2002), the Godlove Award of the Inter-Society Color Council, U.S.A (2007), and Honorary Fellowship of the Society of Dyers and Colourists (2009). In 2009 he was appointed an Officer of the British Empire (OBE) for 'services to the field of colour science and to young people through Crusaders'.



**Dr Michael R. Pointer** received his Ph.D from Imperial College, London, working with David Wright. He then worked in the Research Division of Kodak Limited on fundamental issues of colour science applied to the photographic system. After periods at the University of Westminster and the National Physical Laboratory, he is now a Visiting Professor at the University of Leeds, as well as working as a consultant scientist. In 1997, he received the Fenton Medal,

The Royal Photographic Society's award for services to the Society. In 2004, he received a Silver Medal from the Society of Dyers and Colourists for 'contributions to colour science'. He has authored over 100 scientific papers, is a Fellow of The Royal Photographic Society and the Institute of Physics, Secretary of CIE Division 1 Vision & Colour, and UK Associate Editor of the journal, *Color Research & Application*.

# ***Series Preface***

Imagine Alice in Wonderland saying this: 'I wonder if I've changed **colour** in the night? Let me think. Was I the same **hue** when I got up this morning? I almost think I can remember feeling a little **less saturated**. But if I'm not the same **x-y value**, the next question is '**What Lab value** in the world am I?' Ah, that's the great puzzle!'

The fourth edition of *Measuring Colour* by Dr Robert W.G. Hunt and Dr Michael R. Pointer is the eleventh book in the Wiley-IS&T Series in Imaging Science and Technology. This excellent text, while not solving the complex puzzle of colour, provides readers with the means to solve their colour puzzle.

The 17-chapter book starts with the basic concepts of colour vision then covers the methodology of converting a spectrum to CIE values (*XYZ* or *Lab*) so one can match colours and detect metamers. Visual models are then used to indicate how colour changes under different viewing conditions and to explain why surface characteristics influence the perception of a given spectrum. The details of using digital cameras to measure colour are an important addition in the fourth edition, as the authors recognise that the CCD and CMOS sensors in digital cameras, together with colour filter arrays and digital signal processing, present a new opportunity to measure spatial variation in colour.

Human beings are very sensitive to colour changes or differences and find it difficult to decide, from a set of colours, for example on a paint palette, which one is wanted. People have a strong sense of memory of preference for the colour of green grass, blue skies or pink sunsets. They notice when a photographic image (from a film or digital camera) of a red tablecloth comes out wrong

or when the sweater that was bought in a shopping mall under tungsten (fluorescent) light looks different in daylight.

Neural scientists can use Functional Magnetic Resonance Imaging to locate where in the brain the perceptions of the colours of the visible spectrum are located. Colour scientists know that each colour has an exact spectral power distribution which can be measured to a high degree of accuracy. Why, then, is colour such a puzzle?

What Alice did not know when she fell down the rabbit hole was that the human visual system can play a lot of tricks on how we perceive colour. The perception of colour depends not just on its native spectrum but also on the spectra of the direct illumination, the ambient illumination and the near and far surround colours. Geometrical patterns can cause local colour changes as seen by the observer, as can adaptation to a uniform colour field. So how can the puzzle called colour be solved when there are so many variables and boundary conditions?

The Mock Turtle might have said: '*What is the use of **studying** all that **colour** stuff, if you **can't measure** it as you go on? It's by far the most confusing thing I ever heard!*'

But then, he was not privy to the fourth edition of *Measuring Colour* which provides a welcome and major contribution to the continuing understanding of the puzzle that is colour.

MICHAEL A. KRISS

*Formerly of the Eastman Kodak Research  
Laboratories and the University of Rochester, USA*

# ***Preface***

## **To the First Edition**

This book is intended to provide the reader with the basic facts needed to measure colour. It is a book about principles, rather than a guide to instruments. With the continual advances in technology, instruments are being improved all the time, so that any description of particular colorimeters, spectroradiometers, or spectrophotometers is likely to become out of date very quickly. For such information, manufacturers' catalogues are a better source of information than books. But the principles of measuring colour are not subject to rapid change, and are therefore appropriate for treatment in the more permanent format offered by books.

Recommendations about the precise way in which the basic principles of colour measurement should be applied have for over 50 years been the province of the International Commission on Illumination (CIE). The second edition of its publication *No. 15, Colorimetry*, includes several new practices, and it is therefore timely to restate the basic principles of colorimetry together with these latest international recommendations on their application; this is the aim of *Measuring Colour*.

Colour is, of course, primarily a sensation experienced by the individual. For this reason, the material has been set in the context of the colour vision properties of the human observer: the first chapter is a review of our current knowledge of colour vision; and the last chapter provides a description of a model of colour vision that can be used to extend colour measurement, beyond the territory covered by the CIE at present, to the field of colour appearance.