David Praekel. 2007. *Lighting*. Λωζάννη: AVA

Light is that narrow band of electromagnetic radiation to which the human eye is sensitive. There are no exact boundaries to the range of visible light, as individuals differ. Typically, our eyes are receptive to a range of wavelengths of light between 400–700 nanometres (nm). (A nanometre is one millionth of a millimetre.)

There is radiant energy above and below the limits of the visible spectrum: above violet is described as ultraviolet, below red as infrared. Imaging systems (film and digital) can pick up these 'colours' and fold them back into visibility. We will look at colour and black-and-white infrared photography in some detail later in the book.

Light has three physical properties that interest the photographer – amplitude (or intensity), the wavelength or frequency and the angle of vibration (or polarization). In layman's terms, intensity can be thought of as the brightness of light and the frequency or wavelength determines its colour; we can barely perceive changes in polarization but this phenomenon can be manipulated photographically with polarizing filters. These are covered in a later section.

Light travels in straight lines, which is why we get shadows. It is also reflected off a mirror or silvered surface at the reverse angle to which it falls, like a billiard ball hitting a cushion. Knowledge of these simple facts allows photographers to shape light using cutters and reflectors. Light can also be bent (refracted), which means we can design lenses to focus images.

Without light, there are no colours. A green pepper only looks green if the corresponding wavelengths (colours) are present in the illuminating light. In orange light that contains no green, a green pepper will look grey and colourless.

We have a photographic definition of the light that contains all the colours and is therefore white – 'daylight' – but photographers use this term in a precise way and it is not quite what you may think. All our 'white' light comes from radiating energy sources – the sun, metal filaments heated by electric current (light bulbs), the light burst from an electric arc (flashgun). There is some implied connection with heat. Photographers use the idea of colour temperature – a spectrum derived from looking at the colours of objects as they heat up – to describe the precise colour of a light source, be it blue-white or yellow-white. Understanding colour temperature and how to control or adjust it is vital to film and digital camera work and the topic is discussed later.

'Light is our paint brush and it is a most willing tool in the hands of the one who studies it with sufficient care.'
Laura Gilpin (American landscape photographer)

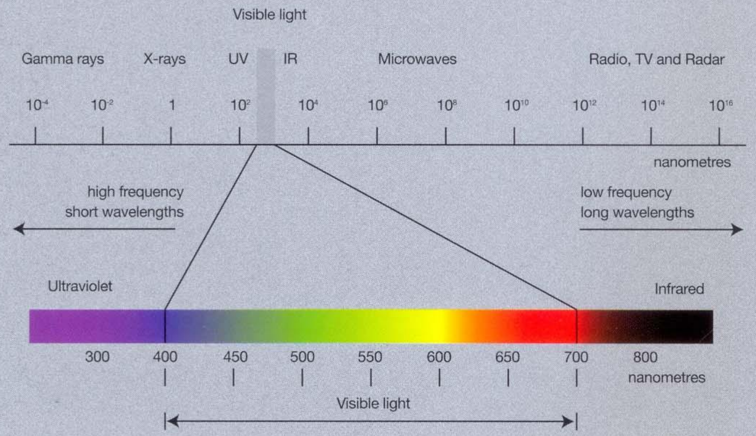
Αποσπασματική παράθεση: (1)

Basic theory

Electromagnetic spectrum

We are familiar with the range of colours within the spectrum that exists between 400–700nm as the colours of the rainbow (red, orange, yellow, green, blue and violet – modern science no longer counts indigo as a usefully separate colour). The colours of the rainbow are what you see when a beam of light cuts through the edge of a drinking glass. This is exactly what happens in the controlled conditions of the physics laboratory using a prism of glass to create the coloured bands of the spectrum by bending (refracting) **white light**. The rainbow colours are spread out because different wavelengths (colours) of light move at different speeds through the denser glass. This simple observation is vital to accurate lens design as it is the source of colour fringes in images from less than perfect lenses. We need to understand the spectrum to know how to use **filters**.

The Electromagnetic Spectrum



filter glass or plastics device that modifies light passing through the camera lens. Computer software module that applies an image effect

white light equal blend of all colours in visible spectrum

The inverse square law

The inverse square law states that the intensity of light observed from a constant source falls off as the square of the distance from the source.

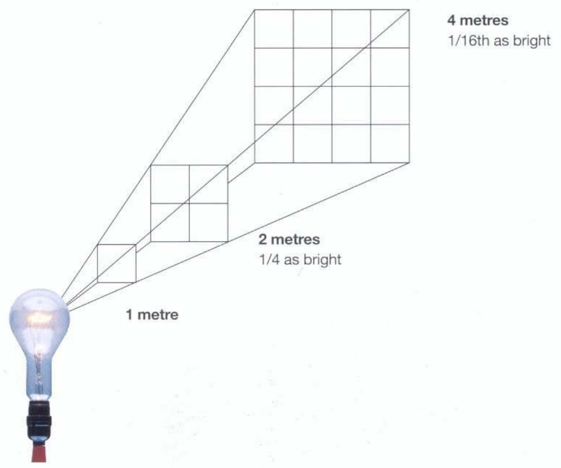
Any light source that spreads its light in all directions obeys this law. In the real world, this is why it gets dark so quickly as you move away from the campfire!

Put simply, the inverse square law means that as you double the distance from the light you quarter the light intensity. In fact, the light falls off as 1 over (inverse) the distance multiplied by itself (squared). The light measured at 2 metres from a light source will be $1/2^2$ or 1/4 the intensity at 1 metre. The light measured at 4 metres from the same source will be $1/4^2$ or 1/16th the intensity at 1 metre.

Photographically speaking, as every stop means a halving or doubling of light, 1/4 the amount of light is 2 stops down; 1/16th of the light is 4 stops down. Therefore, a light meter reading f/16 at 1 metre, for example, would read f/8 at 2 metres and would read f/4 at 4 metres.

It is important to understand this law, as it is one of the main ways in which light intensity can be controlled in the studio. The only light source that does not obey this law is the sun – as any distance we move something on earth is trivial compared to the distance from the earth to the sun.

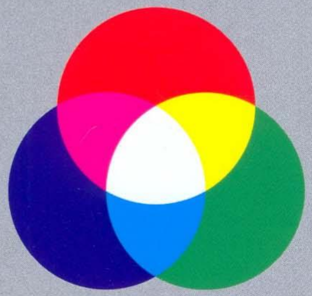
Inverse square law



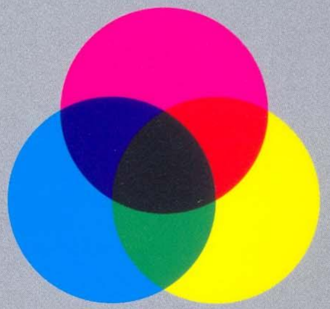
White light and primary colours

White light passing through a prism creates all the colours of the rainbow, but only three of these colours are necessary to make up all the others. These are called the additive primary colours – red, green and blue – familiar from the 'RGB' label used in TV, computer monitor and video 'speak'. Add equal quantities of red, green and blue light to make white.

Additive colour mixing



Subtractive colour mixing



Subtract any one of these colours – red, green or blue – from white light and you are left with a combination of the remaining primaries. The colours from the remaining combinations – cyan, magenta and yellow – are the so-called subtractive primaries. RGB is the additive world of light and of the digital sensor; CMY is the world of reflected light, where these colours are used as dyes or pigments in our inks on white paper or as chemical dyes in film, to act as filters on white light to create the range of visible colours. Add equal quantities of cyan, magenta and yellow inks and you get black.*

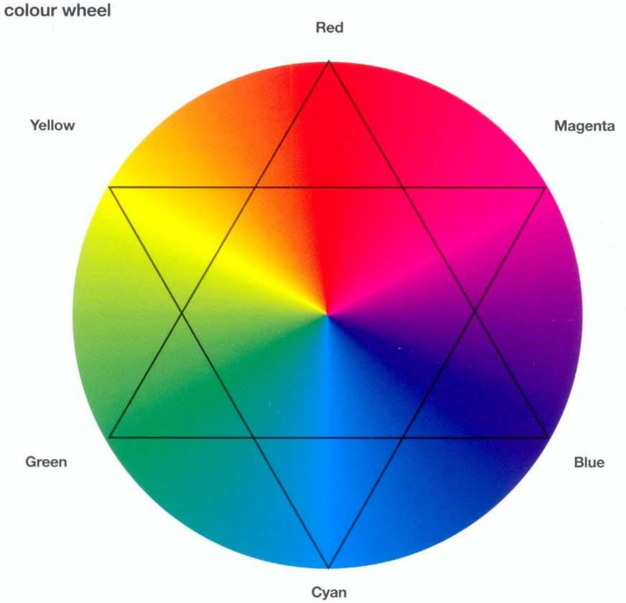
* True black is added in four-colour (CMYK) printing, as real-world ink pigments are not pure enough to give black, instead giving a dirty purple-brown.

Photographers find it useful to put the colours of the spectrum on a wheel, which helps in understanding how to filter and manipulate light. Red, green and blue will be found 120° apart on the wheel (at the 12 o'clock, 4 o'clock and 8 o'clock positions). All other colours as combinations of the three primaries lie in between. In colour correction, you use opposite colours on the wheel to cancel each other out. For instance, an image with a particular blue cast can be corrected by adding the yellow that lies opposite that blue on the colour wheel. The black-and-white photographer, wanting to darken the sky's appearance, would choose a red filter opposite to the sky's colour (cyan) on the wheel.

Digital camera users will often find hue (colour) adjustments described as a certain number of degrees. This represents a shift in colour around the colour wheel through an arc of that angle, rather like moving a few minutes round a clock face.

Adjustments to colour images in computer software make sense when you understand the colour wheel. Imagine a strip taken from round the edge of the wheel being used to show every possible colour – it would start and end at the same place (cyan, in the case of the Photoshop sliders).

The colour wheel



Colour theory

Colour temperature

Phrases like 'red hot' and 'white hot' are in everyday use. In the first Industrial Revolution of the late 18th and early 19th centuries, it became important to judge accurately the temperature of industrial processes such as smelting and glass-making. Traditionally, this was done by observing the colour of the furnace. William Thompson, the 19th-century physicist and later Lord Kelvin, formalised these observations and the unit of **colour temperature**, kelvin (not degrees kelvin), is named after him.

If a dull block of iron is heated to white-hot, it passes through the full range of colours from dull red through yellow. The colour temperature scale relates directly to this idea of the colour change seen when heating an object. Kelvin took the actual temperature and added the value of absolute zero to create his scale. The block of iron analogy runs out at 'white-hot', as in the air this is where the iron would begin to burn (oxidize). Exclude the air by putting the block in a vacuum; keep pumping in more energy and the colour will change from white to blue (we have just invented the light bulb).

Colour temperature

Colour	Description	Actual temperature		Colour temperature (kelvin)
	Extremely dull red	480°C	Absolute zero +273	753K
	Very dark red	630°C		903K
	Dark red	750°C		1023K
	Cherry red	815°C		1088K
	Light cherry red	900°C		1173K
	Orange red	990°C		1263K
	Yellow	1150°C		1423K
	Yellow-white	1330°C		1603K

Colour temperature of common light sources

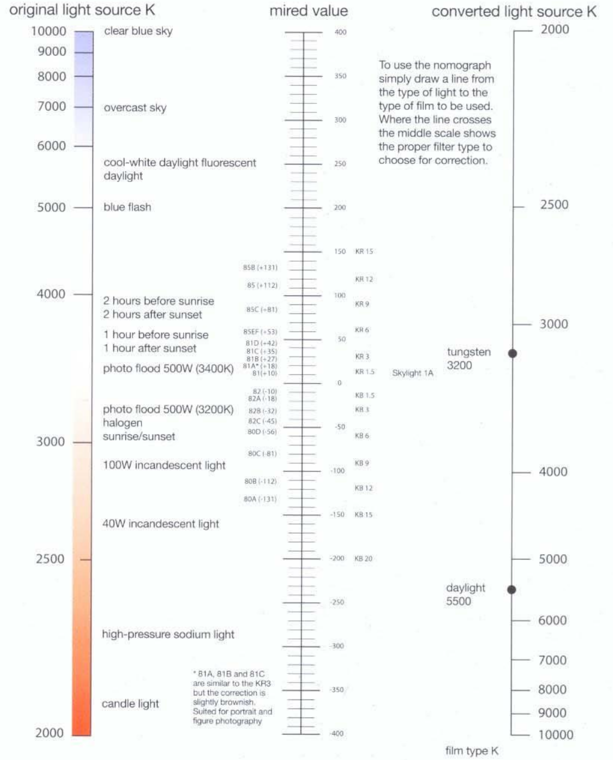
Candles and oil lamps	2000K
Household light bulbs	2900K
Sunrise or sunset lighting	3100K
Studio tungsten	3200K
Photoflood lamps (overrun)	3400K
Morning/evening sunshine	3800K
Noon daylight/electronic flash	5500K
Overcast sky	7000K
Clear blue sky	10000K
Reflections from clear blue sky in shade	16000K

The sun is a source of radiant energy. Many of our light sources are incandescent (glowing) sources, usually created by heating a metal filament in a vacuum. In colour photography, we need to take into account the quality (temperature) of the illuminating light. Time of day has a big effect on the colour of light.To be able to photograph in a range of lighting conditions, yet keep white appearing as white and not blue-white or yellow-white, we need to be able to either filter the light source or use an appropriate film stock for that light. Digital cameras too can be adjusted to give neutral whites across a range of light sources with varying colour temperatures.

colour temperature measure of 'whiteness' of light, measured in kelvin

Working out which filter will convert the colour of one light source to another is done using a nomograph. Simply draw a line connecting the colour temperature of the original light source with the converted source. The necessary **mired** shift to achieve the change can be read off from the centre scale. The filters that produce the necessary shift are also shown. This nomograph shows only photographic filters for use on the camera; you will find other charts that additionally show the coloured gels that can be used on the light sources themselves, a practice more common in the film and TV industries.

A nomograph



mired from **mi**cro **re**ciprocal **d**egrees – pronounced 'my-red'. One million divided by colour temperature; commonly used unit when converting from one colour temperature to another using filters – also mired shift (Expression reciprocal mega kelvin beginning to be used.)

Colour balance
The human eye and brain will adjust our perception of white whatever the colour quality of the illuminating light source. Digital cameras make something like this adjustment when switched into automatic white balance (AWB). With colour film, if adjustment is needed to avoid a **colour cast** – and it usually will need at least fine-tuning – then a filter has to be used.

Colour films are balanced to give neutral results with very specific colour temperatures. Daylight film (see pages 58-9 for a description of photographic daylight) is balanced for a colour temperature of 5500K. Tungsten film is balanced for a temperature of 3200K. (Older technical books refer to two types of tungsten film – Type A balanced for 3400K and Type B at 3200K.)

By the correct use of conversion filters, daylight film can be balanced for use with artificial lights or artificial light film (tungsten) balanced for daylight use. These are the extreme cases; more likely is the subtle adjustment necessary of film to a light source that is close to, but not precisely at, the film's specified colour temperature.

Colour conversion filters let the photographer match the colour temperature of the lighting to the film in use. They can also be used to modify the **colour balance**. In Europe, the filters are described as KB (bluish) filters, which increase colour temperature, or KR (reddish) filters, which reduce it.

There is an older system of describing filters called the Wratten numbering scheme. This was named after Frederick Wratten who sold his coloured filter company to Eastman Kodak at the beginning of the 20th century. Wratten numbers can seem confusing but are still used in both the USA and the UK today.

The Wratten colour conversion filters in the deep blue 80 series and deep orange 85 series are used for making major shifts in colour temperature. The Wratten 81 series filters (yellow-amber) lower the colour temperature and 82 series filters (light blue) raise the colour temperature over a range of several hundred degrees. They are referred to as **colour balancing** or **light balancing filters**. These raise or lower colour temperature in much smaller steps than the colour conversion filters.

colour balance truthfulness of colours across the spectrum
colour balancing (light balancing) filters amber and blue filters used when making colour temperature changes, sometimes referred to as warming or cooling filters respectively or light balancing filters
colour cast unwanted, overall colour change in an image
colour conversion filters deep blue and orange filters used to achieve significant shifts in colour temperature, and to correct white balance when using film and lighting of a different target colour temperature
filter factor filters cut out certain wavelengths of light, reducing the total amount of light that reaches the film or sensor – for a correct exposure an allowance must be made. A filter that cuts out half the light will have a factor of x2 and one stop must be added to the exposure indicated by an incident light meter reading. On the whole TTL meters in cameras are not affected

Matching colour film to light source

Colour	Balanced for	Filter required		
		Daylight (or electronic flash)	Photo lamp (3400K)	Tungsten (3200K)
Daylight	Daylight, or electronic flash (5500K)	None	80B/KB 12	80A/KB 15
Tungsten	(3200K)	85B/KR 15	81A	None

Filters

Europe	Wratten	Colour	Effect
KR 1.5	Skylight 1A	light salmon pink	Reduces bluish cast in scenic shots and snow scenes or pictures taken around noon. Absorbs UV, commonly used to protect the lens. No light loss.
KR 3		slightly darker salmon pink	Stronger effect than the Skylight filter, especially useful for hazy sunlight, cloudy overcast days and at higher elevations. Useful with Kodachrome to avoid blue haze.
	81A 81B 81C	slight brown	Similar to KR 3 but browner. Especially suited for portrait and figure photography where skin tones are more pleasingly reproduced. Each creates a 100K shift in colour correction.
KR 6	81E 81F	medium reddish	For daylight colour film shot in deep shadows with sunny illumination or for architectural interiors (churches) on cloudy days.
KR 9		reddish	More effective than KR 6. For heavy daylight shadows and underwater photography.
KR 12	85	reddish-brown	Converts tungsten-balanced transparency film (old Type A 3400K) to daylight (5500K).
KR 15	85B	red-brown	Reduces colour temperature by 2300K to balance tungsten film 3200K to daylight. **Filter factor** x2.
KB 1.5	82A	slightly blue	Removes reddish-yellow cast during morning and evening light. It increases the colour temperature by 200K.
KB 3	82B	bluish	Stronger effect than the KB 1.5 and corrects the red cast from tungsten illumination when using Tungsten film.
KB 6	82C	medium violet blue	Increases colour temperature by 1400K. Clears strong red cast from early morning and evening light. Often used for theatre and stage photography. Increases colour temperature by 1700K and has a stronger effect than KB 3.
KB 9	80C	blue	Increases colour temperature by 1700K and has a stronger effect than KB 6.
KB 12	80B	blue	Converts daylight slide film to use with 3400K lighting (photofloods or halogen lamps). Filter factor x3.
KB 15	80A	blue	Use with daylight film under 3200K tungsten lamps (60W and 100W). Filter factor x4.
KB 20		deep blue	Increases colour temperature by 2700K; used with candlelight. Used in the movie industry to film night-time scenes during daylight. Filter factor x5.

Colour correction

Colour correction or **colour compensating (CC) filters** have traditionally been used to make changes in the overall colour balance of images or to correct colour casts. They can also be used to correct manufacturing batch variations in colour film, slight deficiencies in studio lighting or reciprocity effects with film. More commonly today, subtle shifts in colour are made after scanning or capture using colour editing software.

CC filters are usually found as gels (not glass) and are available in cyan, magenta, yellow, red, green and blue in a range of densities rated 05, and 10–50 in units of ten. Intermediate values can be made by stacking filters together. The red filters are still commonly used in underwater photography to re-balance colour.

Colour correction filters – exposure increase in stops

Density	0.05	0.10	0.20	0.30	0.40	0.50
Cyan	CC05C +1/3	CC10C +1/3	CC20C +1/3	CC30C +2/3	CC40C +2/3	CC50C +1
Magenta	CC05M +1/3	CC10M +1/3	CC20M +1/3	CC30M +2/3	CC40M +2/3	CC50M +2/3
Yellow	CC05Y –	CC10Y +1/3	CC20Y +1/3	CC30Y +1/3	CC40Y +1/3	CC50Y +2/3
Red	CC05R +1/3	CC10R +1/3	CC20R +1/3	CC30R +2/3	CC40R +2/3	CC50R +1
Green	CC05G +1/3	CC10G +1/3	CC20G +1/3	CC30G +2/3	CC40G +2/3	CC50G +1
Blue	CC05B +1/3	CC10B +1/3	CC20B +2/3	CC30B +2/3	CC40B +1	CC50B +1 1/3

colour compensating (CC) filters weak cyan, yellow, magenta, red, green and blue filters used when making minor colour changes to remove a colour cast, for instance. Also known as CC filters

Warming and cooling filters

Though technically the Wratten 81 series filters warm up and the 82 series cooling filters are designed to rebalance film white point accurately, they are more commonly used for aesthetic purposes. The fashion photographer Terence Donovan once pointed out that a client never criticised an image as being too warm.

Kirkhaugh, Northumberland (below)

Comparison of the effects of 81 series warming and 82 series cooling filters.

Photographer: David Präkel.

Technical summary: Nikon D100, 18–35 AF-D f3.5/4.5 at 35mm, 1/500 at f/11 (no filter) **ISO** 200.

81E/F

81B

82A

81D

81A

82B

81C

No filter

82C

ISO International Organization for Standardization. The body that sets standards for film speeds and matching digital sensitivity

White balance

The human eye and brain keep 'white' the things we know are white, whatever the colour quality of the lights we are under. To our eyes, the white paper of the pages of a book are white whether we are reading them by daylight or under tungsten or tungsten halogen lights indoors.

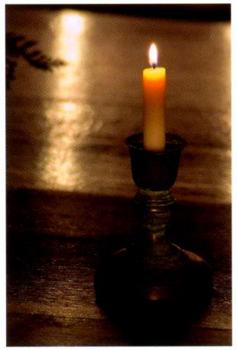
Digital cameras represent colours as a combined level of red, green and blue light. The highest numbers they record are 255 in an 8-bit file, so R255, G255, B255 represents white light, just as R0, G0, B0 represents no light – black in other words. It follows that as long as the RGB numbers are the same, some level of grey will be represented. Effectively, what the digital camera does to achieve automatic white balance (AWB) is to look for pixels where the RGB numbers are very close. Those pixels are then 'corrected' by evening up the numbers and making the colour a neutral shade of grey. That numerical shift applied to all the other colours in the image should effect a correct **white balance**.

In many instances – especially where mixed colour temperature light sources are present – automatic white balance does a good job of achieving acceptable results. Alternatively, the camera user can override the automatic setting by choosing a preset colour temperature value from Daylight, Tungsten, and usually a range of Fluorescent settings. Some cameras offer colour temperature choice in kelvin.

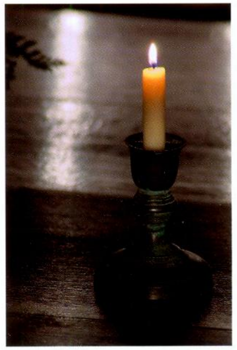
The best option of all is to use the camera to measure the white balance from a neutral reference. The custom white balance feature is useful where difficult colour temperature conditions occur – a daylight and fluorescent mix, for example. An image of a white or **grey card** is captured under the light and that is designated as neutral; the camera then assigns a specific colour balance for those lighting conditions. Some advanced professional digital cameras have built-in meters and can achieve a correct white balance at the press of a single button.

Not only does the Camera RAW (12-bit) digital file format have the capability of recording a range of possible exposures in one file but it also gives after-the-fact adjustment of colour temperature across a wide range. Though it is best to get white balance sorted at the time of exposure, the RAW format will allow the production of a wide range of colour temperature instances from the single file. This can be achieved by choosing a colour temperature from a pick list (Daylight, Cloudy, Shade…) and fine-tuning that value. Alternatively, the computer can calculate a value as described above, or you can use a grey eyedropper to sample a colour in the image that should be neutral and have the computer use that as its white balance target.

The temptation to over-correct white balance should be resisted. We are happy to accept some yellow in the images of light from candles or oil lamps. At the other end of the colour temperature spectrum, we expect reflected light from snow to be a little blue. Over-correcting snow and candlelight images for technically perfect whites creates an oddly sterile look.



As shot



Tungsten balance

Over-corrected

By candlelight (above)

Left: As shot, the camera produces a warm yellow image from the mix of candlelight and tungsten halogen light reflected from the table surface.

Centre: Tungsten balance (which in this instance is the same colour temperature you get by asking the computer to automatically calculate a value) shows the reflected light as pure white and leaves the candle light with some yellow colouration.

Right: Correcting for the candle light alone produces an overall blue cast elsewhere, isolating the candle and its flame. The image is technically correct but the overall effect is absurd.

Photographer: David Präkel.

Technical summary: Nikon D100 70–300mm f/4–5.6 AF-D zoom at 190mm, 1/4 sec at f/4.8, White Balance Auto.

grey card standard piece of card that reflects 18% of the light falling on it to provide an exact mid-tone light reading

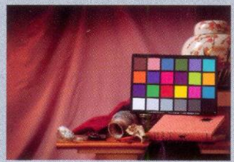
white balance adjusting for the colour temperature of the illuminating light, so white and neutral colours appear truly neutral and do not have a colour cast

Using a colour checker

When technically correct colour is important it helps to use a known colour reference. Called colour checkers or colour separation guides they can vary in both price and quality, but any is better than none. The best known is the Gretag-Macbeth Colour Checker chart.

Once a shot has been set up it is first captured with the colour checker in place. The chart should be positioned so as not to reflect light back into the camera; it needs to be roughly square on and large enough in the frame. A second exposure is then taken with the colour checker removed. This will be the image used for the client or publication. The lighting must be the same for both exposures.

Colour corrections and level adjustments can now be made with image editing software using the chart as a reference, and the values of these changes recorded. These values are then applied to the second image, effecting a colour correction to the image for use based on the first image that contained the colour chart.



Allegory on the vanities of human life
(after Harmen Steenwyck, Dutch 17th-century painter)

Left: Still-life image as shot with colour checker in place.
Centre: Image corrected for colour, brightness and contrast on computer.
Right: Recorded changes made to final image for client.

Photographer: David Präkel.

Technical summary: Nikon D100 60mm Micro-Nikkor AF-D, 1/4 at f/11, mixed daylight and tungsten (on backdrop).

Filters for black-and-white photography

In black-and-white photography, filters are used to control the grey tones in which the various colours reproduce. Without filters some colours will reproduce only weakly. Certain shades of red and green, for example, reproduce as close grey tones in a black-and-white print and can only be differentiated by the use of coloured filters. Skies can often appear overexposed and white, as film is naturally sensitive to blue light. Filters are also used to control the contrast in black-and-white images.

To understand the action of a photographic filter you need to know that filters pass light of their own colour but block the other colours in the spectrum. A red filter will block out much of the blue and green light from a scene, so blue and green coloured subjects will reproduce darker than the red light, which passes through. A red filter can therefore be used to darken blue skies. The general rules in using filters with black-and-white film are: to darken a colour, use a filter of the complementary colour (opposite on the colour wheel); to lighten a colour, use a filter of the same or similar colour.

Many filters still have descriptive names and some photographers will refer to 'sky filters', for instance, as the collective name for yellow, orange or red filters, all of which act to darken the blue to cyan colours of the sky.

It is also important to remember that because filters cut down the amount of light reaching the film, some compensation has to be made by increasing the exposure. This varies depending on the filter and the manufacturer will give a filter factor that is commonly engraved on the filter mount, in the case of a screw-in glass filter.

Although you can easily see the effect of the filter through your SLR camera lens, it is not always safe to rely on the meter reading. Some camera meters are only accurate when measuring a mixture of all wavelengths and not filtered light. It is safest to take a reading without the filter, fit the filter and increase the exposure as suggested in the table opposite or according to the filter manufacturer's recommendations.

Effect of filters

Colour original scene

Black-and-white

Deep Red Wratten 29

Red Wratten 25

Orange Wratten 22

Yellow Wratten 12

Green YG

Filter description	Wratten number	Use	Exposure increase
Medium yellow	8	Darkens blue skies a little to make clouds more visible. Leaves are slightly lighter. Reduces haze. Crisps snow.	1–1½ stops
Yellow-green	11	Corrects black-and-white film sensitivity for tungsten lighting. A 'spring and summer' filter that lightens leaves. Lightens white skin to natural appearance.	1½ stops
Deep yellow	12	Can be thought of as a 'minus blue' filter that darkens blue skies.	1½–2 stops
Dark yellow	15	Darkens blue skies to increase cloud reproduction.	2 stops
Yellow-orange	16	Has more effect on skies than a yellow filter. Used in portraiture to reduce effect of skin blemishes.	1⅔ stops
Orange	22	Greater effect on skies than yellow-orange, especially at sunrise and sunset. Lightens brickwork and darkens leaves. Smooths skin tone.	2 stops
Red	25	Dramatically darkens blue skies, deepens shadows and enhances contrast.	3 stops
Dark red/strong red	29	Even stronger effect than red. Can be used with telephoto lenses to darken sky close to a distant horizon.	4 stops
Magenta	32	Can be thought of as a 'minus green' filter that darkens greens.	1⅔ stops
Light blue-green	44	Can be thought of as a 'minus red' filter that darkens reds.	2½ stops
Deep blue	47	Emphasises haze to increase aerial perspective in landscapes.	2⅓ stops
Deep green	58	Lightens foliage.	3 stops

Filter factor	f-stop	Filter factor	f-stop	Filter factor	f-stop
x1	-	x3.2	1 ⅔	x10	3 ⅓
x1.2	¼	x3.4	1 ¾	x11.4	3 ½
x1.25	⅓	x4	2	x12.6	3 ⅔
x1.4	½	x4.8	2 ¼	x13.5	3 ¾
x1.6	⅔	x5	2 ⅓	x16	4
x1.7	¾	x5.7	2 ½	x32	5
x2	1	x6.4	2 ⅔	x64	6
x2.4	1 ¼	x6.8	2 ¾	x1000	10
x2.5	1 ⅓	x8	3	x10 000	13
x2.8	1 ½	x9.5	3 ¼	x1million	20

Exposure

Exposure value

Exposure Value (EV) numbers are a way to describe exposure settings with just a single number, instead of the usual f-stop and shutter speed combinations. A single number represents all combinations of apertures and shutter speeds that give the same exposure. For example, EV10 in the table can represent any combination of aperture and shutter speed from 4 sec at f/64 to 1/1000 sec at f/1.

Professional standard **light (exposure) meters** commonly have a display of the measured light in EV numbers in addition to the f-stops and shutter speeds. The EV unit is one stop. Many professional photographers prefer to think in terms of exposure values as it helps them deal with the light and not the camera settings. For any given amount of light, there are many ways in which the camera settings of aperture and shutter speed can be combined to produce a correct exposure in accordance with the law of reciprocity. This states that an increase in light intensity must be matched by a corresponding decrease in the duration of the light to achieve a correct exposure. It was once common for amateur mid-20th century cameras to be set using a single EV number, now only certain professional camera lenses retain this convenience. The EV number is transferred from the light meter to the lens, which locks the shutter speeds and apertures in the appropriate relationship, from which a suitable pair can then be chosen.

Table of exposure values (ISO 100)

	f-number												
shutter (s)	1	1.4	2	2.8	4	5.6	8	11	16	22	32	45	64
60	-6	-5	-4	-3	-2	-1	0	1	2	3	4	5	6
30	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7
15	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8
8	-3	-2	-1	0	1	2	3	4	5	6	7	8	9
4	-2	-1	0	1	2	3	4	5	6	7	8	9	10
2	-1	0	1	2	3	4	5	6	7	8	9	10	11
1	0	1	2	3	4	5	6	7	8	9	10	11	12
1/2	1	2	3	4	5	6	7	8	9	10	11	12	13
1/4	2	3	4	5	6	7	8	9	10	11	12	13	14
1/8	3	4	5	6	7	8	9	10	11	12	13	14	15
1/15	4	5	6	7	8	9	10	11	12	13	14	15	16
1/30	5	6	7	8	9	10	11	12	13	14	15	16	17
1/60	6	7	8	9	10	11	12	13	14	15	16	17	18
1/125	7	8	9	10	11	12	13	14	15	16	17	18	19
1/250	8	9	10	11	12	13	14	15	16	17	18	19	20
1/500	9	10	11	12	13	14	15	16	17	18	19	20	21
1/1000	10	11	12	13	14	15	16	17	18	19	20	21	22
1/2000	11	12	13	14	15	16	17	18	19	20	21	22	23
1/4000	12	13	14	15	16	17	18	19	20	21	22	23	24
1/8000	13	14	15	16	17	18	19	20	21	22	23	24	25

Exposure Value (EV) number single number representing a range of equivalent combinations of aperture and shutter speed. Exposure Value unit is one stop
light meter (exposure meter) measures intensity of light for photography, giving value as a combination of shutter speed and aperture or a single EV number for a given film speed or sensitivity

Light meters

Light meters are designed either to measure light reflected from the subject (the meter in your camera) or to measure light falling on the subject (a hand-held incident light meter).

Modern cameras use reflected light meters that work **t**hrough **t**he **l**ens (**TTL**). They usually have adjustable sensitivity patterns. Centre weighting is common as this takes more account of the subject at the centre of the frame. So-called spot metering in cameras is better thought of as small-area metering; a true **spot meter** measures at a much narrower angle between 1° and 5°, which makes many camera 'spots' look crude indeed. However, camera spot meters are useful for making average readings from highlight and shadow areas. Evaluative metering is now found in many forms, with all major manufacturers having their own brand names. Essentially, the image is broken down into metering areas, sometimes over 1000. The brightness distribution that is measured is compared against a database of image measurements and compensation made accordingly. The modern meter will take into account not only the focal length of the lens but also the point on which the camera is focused, as well as the brightness distribution. Sophisticated modern meters will give perfectly acceptable results 90 per cent of the time but they can be fooled. More importantly, your visualisation of the scene may not be what the designers had in mind when programming the camera.

Hand-held incident light meters usually have a diffuser (sometimes called a lumisphere) over the light-sensitive cell to average the light falling on the subject. On some models, this can be moved aside and the meter used as an averaging reflected light meter by pointing it at the subject. Spot meters are simply reflected light meters that measure from a much smaller part of the subject. True spot meters use the narrowest of acceptance angles to pick the tiniest part of the subject for measurement. They usually use a simple telescope viewfinder. Some hand-held meters incorporate a zoom lens viewfinder to pick off spot readings from tiny areas of the subject ranging from 1° to 5°.

Typical professional light meter with reflective spot metering and incident light meter modes for flash and ambient light.

spot meter light meter that takes a reflected light reading from a very small area of the subject (1–4° acceptance angle). Camera spot meter functions are commonly not as selective unless telephoto lens is used
TTL (through the lens) reflected light meter in cameras that measures light through the taking lens

Exposure compensation

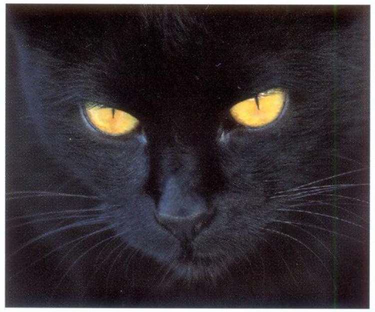
Reflected light meters are easily fooled as they expect to see an average scene. The reflectance of the average scene equates to 18% grey. Light meters try to interpret what they 'see' in terms of the average scene. A predominantly light subject will give too short a suggested exposure, often **underexposed** by 2 stops. Similarly, an all-dark subject will result in **overexposure** by up to 2 stops. Exposure compensation or manual override will be needed when the subject is not average – black dogs or white flowers filling the frame, for example.

Exposure troubleshooting

Side lighting or back lighting	Increase exposure by 1 stop
Beach or snow scenes	Increase exposure by 1 stop
Sunsets or scenes with bright light source	Increase exposure by 1 stop
To get a natural look for a very light or white subject	Increase exposure by at least 1 stop
In extremely contrasty lighting; shadow areas have important detail and are much darker than brightly lit areas	Increase exposure by 2 stops
Background is much darker and bigger than subject (a light skinned person against a dark wall)	Decrease exposure by 1 stop
To get a natural look for a very dark subject	Decrease exposure by at least 1 stop
Extremely dark background takes up a large part of the image	Decrease exposure by 2 stops

CHANGE	To increase by 2 stops	To increase by 1 stop	To decrease by 1 stop	To decrease by 2 stops
aperture (example)	Open aperture 2 stops (f8–f4)	Open aperture 1 stop (f8–f5.6)	Close aperture 1 stop (f8–f11)	Close aperture 2 stops (f8–f16)
OR shutter speed (example)	Reduce shutter speed 2 stops (1/60–1/15)	Reduce shutter speed 1 stop (1/60–1/30)	Increase shutter speed 1 stop (1/60–1/125)	Increase shutter speed 2 stops (1/60–1/250)
OR EV compensation	Set to +2	Set to +1	Set to –1	Set to –2
OR **film speed/sensitivity** (example)	Quarter (ISO 400–ISO 100)	Half (ISO 400–ISO 200)	Double (ISO 400–ISO 800)	Quadruple (ISO 400–ISO 1600)

film speed/sensitivity measure of photographic film's sensitivity to light. See ISO
overexposure images created with too much light, having no shadows or dark tones. See underexposure
underexposure images created with too little light, no highlights or light tones. See overexposure



Black cat (left)
The kind of subject that demands accurate metering. A reflected meter (in-camera) reading would produce – without exposure compensation – a mid-grey image of this cat.
Photographer: Brad Kim.
Technical summary: Canon EOS 10D, Canon EF 70–200mm f/2.8L zoom lens at 200mm focal length. Underexposed by 2 stops from the camera meter reading. Photoshop levels applied for final tonal adjustment.

White tulips (below)
Another difficult subject to expose by using a reading from a reflected light meter. Without positive EV compensation (up to 2 stops overexposure on reading) these tulips would be grey.
Photographer: Marion Luijten.
Technical summary: Canon 10D Sigma 105mm 1/125 sec at f/13 ISO 400, lit by two Bowens Esprit 500DX monoblocs, one with softbox and one with umbrella.

Techniques for the perfect exposure

There are several ways of getting accurate meter readings. Never forget that meters always read for middle grey (18% reflectance).

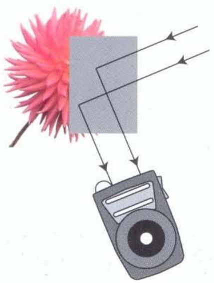
Take a general reading

Often a reading from an entire subject gives a good exposure. If the subject is predominantly light coloured or white then add light. (It is not intuitive. My memory aide is that 'Bright Students are A Plus' – so if the subject is bright I add (plus) 1 stop or more.) Conversely, for predominantly dark subjects cut down on the reading suggested by the meter. For the proverbial black cat, you will need to reduce the exposure by up to 2 stops.

Reflected light metering.

Substitute metering – use a grey card

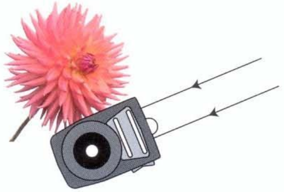
An 18% reflectance grey card gives the meter what it wants to see. Hold the card in front of the subject and meter off that. Set the camera ignoring what the meter now tells you (if you leave the camera on Automatic it will automatically get it wrong – you must use Manual control with a grey card). If you do not have a grey card, use your hand held in front of the subject. Don't let shadows fall from your fingers and hold your hand out flat. Caucasian skin needs a stop more than the reading, so if the meter reads 1/125 at f/5.6 give it 1/60 at f/5.6. Brown skin almost matches a grey card perfectly. Dark skin may need up to 1 stop less than the meter suggests. Find out how your skin relates to a grey card reading.



Substitute light metering with 18% reflectance grey card.

Measure the light falling on the subject

Using a hand-held incident light meter. Incident light meters supply an averaged reading of the light falling on the subject and do not read dark and light areas on the subject. This can be a good idea in extreme lighting conditions. Remember to point the meter back towards the camera position.



Incident light metering.

Average the readings taken from the shadows and highlight

As meters read middle grey, the correct reading will be somewhere between the reading for the darkest and lightest areas of the subject. If the reading is 1/250 at f/5.6 at the lightest part and 1/15 at f/5.6, shoot at 1/60 at f/5.6, which is in between the two.

Bracketing

One way to get the right exposure by playing it safe and taking additional under- and overexposed images. This may not be possible with some fast-changing subjects. Take any type of meter reading then shoot additional frames whole or half stops under- and overexposed in a series of three or five frames. Some cameras will do this automatically. This cannot work with candid photography where you get one shot only, so do not rely on the technique too much. It is great for still-life though.

Meter the shadows and compensate

Metering shadows and compensating for them will guarantee that you get shadow detail. Take a meter reading from the darkest area where you want detail (cat's black fur, for instance). Then expose at 2 stops less. If the meter says 1/60 at f/2.8 use 2 stops less – 1/60 at f/5.6.

bracketing intentional over- and underexposure from the indicated exposure, usually in whole or half stops

Subject contrast

Subject contrast is the difference between the lightest and darkest tones in an evenly lit subject. For someone dressed all over in grey there would be no contrast but someone dressed in a white shirt under a black jacket would have an inherent contrast of about 6 stops. To confirm this: on a bright but overcast day where the incident light reading was 12.5EV (ISO 100) a reflected reading from a white shirt was 15.5EV while that taken from a black jacket was 9.5EV. (Note that the incident light reading representing middle grey falls at exactly the half way point, three stops darker than white but three stops lighter than black.) This shows a range of 6 stops (15.5 – 9.5 = 6) which – referring to the stops to ratio table – gives a subject contrast of 64:1. A subject contrast of 6 stops is already challenging the ability of some colour reversal films even before any lighting has been added.

Subject contrast can be thought of as being the difference between the amounts of light reflected back by the different materials of the subject. We deal with subject contrast alone in open lighting in the real world; this is lighting that is flat and even, without shadows. If reflectors are introduced to highlight parts of the subject, or the subject itself is moved into areas of part shade, then we are no longer just dealing with subject contrast. In particular, as soon as we go into the studio and build up our own lighting things become more complicated and contrasty.

1 stop = 2:1
1.5 stops = 3:1
2 stops = 4:1
3 stops = 8:1
4 stops = 16:1
5 stops = 32:1
6 stops = 64:1
7 stops = 128:1

High contrast is when the ratio between the lightest and the darkest tones is greater than 32:1.

Low contrast is when the ratio is less than 2:1

Motorcycle engine (left)

The subject contrast of this motorcycl engine already pushes the limitations digital capture at 7-stops range on a cloudy overcast day. In bright sunshin the reflections would push this range higher to 10–12 stops, meaning the highlight detail or shadow detail would be lost, depending on the chosen exposure. Dull days are sometimes th best for high contrast subjects.

Photographer: David Präkel.

Technical summary: Nikon D100, 28–85 f/3.5–5.6 AF-D Nikkor Zoom at 35mm, 1/180 f/11, ISO 200.

Subject brightness range

Subject brightness range is the combination of subject contrast and lighting contrast. If a subject with a contrast of 4:1 is lit by lights in a ratio of 8:1 then the overall subject brightness range will end up as 32:1. (This represents a range of 5 stops that can just be captured on transparency material.) Remember:

subject brightness range = subject contrast x lighting ratio

Subject brightness range can be thought of as the final contrast that the camera 'sees', made up of the combination of the inherent contrast in the subject and the contrast in the lighting applied. This is the reason it becomes so important in the studio to learn to see how the camera 'sees'.

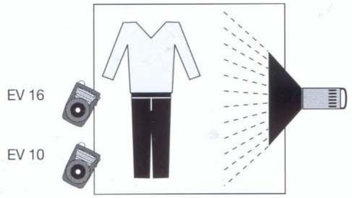
Film and digital sensors are limited in the subject brightness range they can handle. Colour transparencies can only accommodate 5 stops, which is a brightness range of about 32:1. Black-and-white and colour negative films have about a 7-stop latitude, though black-and-white film can be under/overexposed and development compensation used to change what parts of the dynamic range are captured. Digital RAW files have greater latitude than JPEGs and can match or better black-and-white and colour negatives.

All too often, beginners will set up spectacular still-life shots or portraits in the studio. To the eye they look dramatic, but the camera sees something quite different and the resulting images are always disappointing. Even if a range of exposures has been made, they will go quickly from having all blocked-up shadow detail to having completely blown-out highlights – even the 'correct' exposure will show some problems with both highlights and shadows. This is because the camera does not have the same ability as the eye to seemingly see into the shadows almost at the same time as seeing detail in the brightness highlights. The trick in the studio is to learn to light for the camera.

Note: The average outdoor scene has a range of 7-stops (128:1) and it will come as no surprise that glossy black-and-white photographic printing paper (wet chemical, not inkjet) has the ability to show exactly this range of densities. Matt paper cannot show the same density of black and has a much more restricted dynamic range.

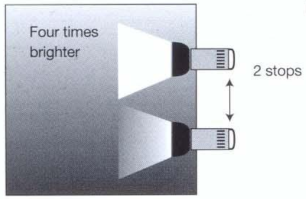
subject brightness range of light to dark presented to the camera by the subject is a combination of the subject contrast and the lighting ratio

Subject brightness range = subject contrast x lighting ratio

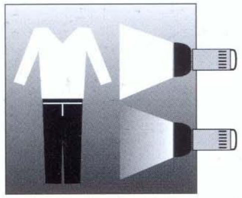


White shirt and black trousers evenly lit
6 stops difference in reflected meter reading
6 stops = 64:1 ratio

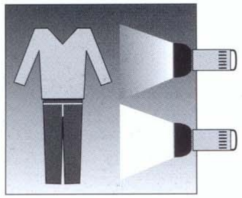
In an unlit studio subject has no contrast



Lighting ratio is 4:1



Light on white shirt is 2 stops brighter than that on black trousers
Lighting ratio is 4:1
Subject contrast is 64:1
Subject brightness range is
4x64:1x1 = 256:1 = 8 stops BUST!
This is greater than 7-stop latitude of negative film or digital. Depending on exposure, you will lose either highlights or shadow detail



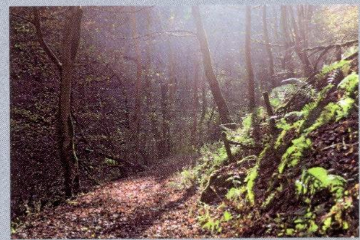
Light on black trousers is 2 stops brighter than that on white shirt
Lighting ratio is 1:4
Subject contrast is 64:1
Subject brightness range is
1x64:4x1 = 64:4 = 16:1 = 4 stops FINE!
Exposure will record highlights and shadow detail

Non-image forming light and lens shading
As well as the light that forms the image by being focused through the camera lens, there is also light that takes no part in image formation. Failure to deal with this light can result in poorly saturated colours or, worse still, lens flare.

Prime lenses are easier to shade with a dedicated lens hood than the now more commonly used zoom lenses with their variable angles of acceptance. A lens hood must not cut off the corners of the wide-angle image and will, therefore, offer little shade for a zoom lens at the other end of its focal length range. An alternative to the lens hood or lens shade is the flag, a simple black plate on the end of an adjustable arm that fits in the camera accessory shoe.

Studio photographers using **large format** cameras take lens shading very seriously and use adjustable bellows lens shades. With the image composed, the bellow shade is adjusted until it visibly crops the image on the view camera ground glass back; it is then backed off until it just disappears outside the image area. This cuts out all stray light.

Unshaded



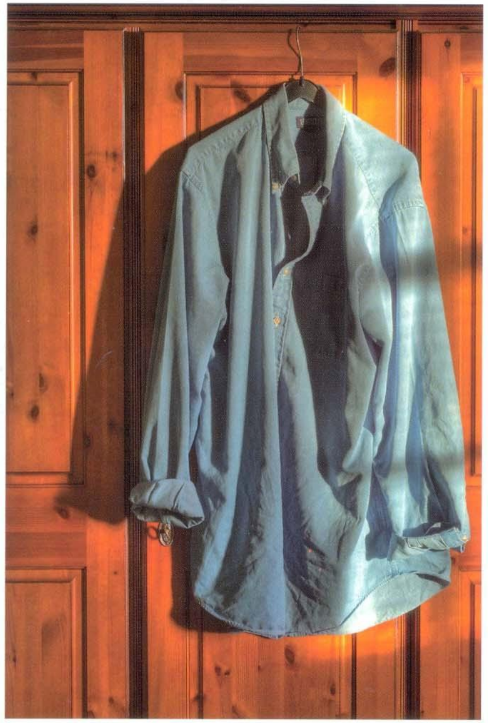
Shaded

Burn Gorge, Northumberland (above)
Left: No lens shading and with sun on the edge of the frame. This **desaturates** colours and causes large lens flare.
Right: Same location, but f/4.8 with lens shaded by outstretched hand to stop sunlight falling on front element.

Photographer: David Präkel.

Technical summary: Nikon D100 60mm Micro-Nikkor AF-D 1/100 at f/5.6, ISO 200.

desaturate/saturate to decrease/increase the strength of all colours
large format sheet film in 5x4, 5x7 and 10x8 inch formats and larger, capable of recording the finest detail; the cameras that use this film



Casual shirt (left)

Series of seven exposures, which were combined into a single 32-bit HDR image. This file was then tone mapped to best show highlight and shadow detail to match human perception of the original scene. If not carefully judged, tone mapping can produce very painterly effects. Created using Photomatix Pro software.

Photographer: David Präkel.

Technical summary: Nikon D100, 60mm Micro-Nikkor AF-D, ISO 400 base exposure 0.4 sec at f/11. Then +2EV, +1EV, 0EV, -1EV, -2EV, -3EV, -4EV.

+2EV +1EV 0EV -1EV -2EV -3EV -4EV

High Dynamic Range (HDR) imagery

The average outdoor scene has a range of 7 stops but many photographers work with the exception and not the average. Their high-contrast scenes will show a range of 10 or even 15 stops. The mass of digital images are commonly stored as 8-bit files that give a range of 8 stops, which is 256:1. Our eyes are capable of an instantaneous 1000:1 range. The eye and brain continually create a composite perception that exceeds even this range, meaning we can see into the shadows and into the highlights where the camera cannot.

The sensors in most digital cameras use 12-bit processing and can capture a range of 12 stops of 4096:1. Though these RAW (unprocessed) files can capture a much wider dynamic range, an 'instance' must be created on the computer that corresponds to just one exposure from the range of possibilities they contain. It would be better if we could take one exposure of the highlights from the RAW file and one from the shadows and combine them. Before Photoshop advances many digital photographers did just that and used layer masks to combine multiple RAW instances, or even different exposures, in one image.

Adobe introduced photographers to HDR imagery and 32-bit files when Photoshop CS2 was launched. This software feature allows users to merge a number of different exposures into a single file to more accurately represent the human perception of the scene. Though only two images are needed – no more than a stop apart – a series of images taken at regular intervals, say +2EV, +1EV, Normal exposure, -1EV and -2EV works best. These are merged into a single file that has an extended dynamic range with detail in both shadows and highlights. You physically have to take a series of images. Different outputs or instances from a single RAW file will not work well. Using images more than a stop apart can create poor quality output with banding. Despite the fact that HDR Merge offers some degree of image content alignment, it is best if the images line up closely. So, using a tripod is also important.

HDR Merge gives the photographer control both over contrast of the final image and of the ways in which highlights are handled.

Although HDR Merge can be used with landscape to create images that retain a natural feel – but with full detail in both highlights and shadows – the technique can have a specific 'look', rather like a super-realist painting. This could become stale if overused.

Neutral density filters

Though it is more usual for photographers to be looking for yet more light or to eke out the available light, there are times when it is useful to be able to reduce light levels. Enter the Neutral density – or ND – filter. These filters reduce all colours in the spectrum evenly and therefore appear to be grey. They are available in a range of 'strengths'. An **ND filter** will reduce the amount of light entering the camera without changing the overall colour balance. They can be used with both colour and black-and-white film (but may push film into reciprocity failure) and digital cameras (though increased noise may result).

In what circumstances would you want to lose light? There are times you might need to create a picture under unexpectedly bright light when you have a high sensitivity film loaded. Some rangefinder camera lens combinations, for example, offer only 1000th of a second as the fastest shutter speed and a minimum aperture of f/16. With 400-speed film loaded, you can rapidly get into situations where you need to cut down the light entering the camera. Sunny conditions in high mountains can very quickly become too bright to work in without the help of ND filters.

Under the creative heading, ND filters allow photographers to use a wider aperture than would be otherwise possible. This permits shallow **depth-of-field** images to be created on bright days outdoors. Conversely, an ND filter will open up the opportunities of long time exposures combined with small apertures. This technique is a much-loved trick of the landscape photographer producing images of waterfalls as it gives the uniquely pictorial combination of milky, moving water and sharp front-to-back focus in the image. Photographs taken at the coast or the water's edge are a favourite for the use of ND filters.

Some manufacturers specify their filters as ND-2, ND-4 and ND-8. These admit half, quarter and one-eighth the light – easy to interpret as 1 stop, 2 stops and 3 stops reduction. Other filter manufacturers use the density 0.3, 0.6 and 0.9 descriptions for the same filters. Two filters can be used together but the filter factors must be multiplied, not added, together. Industrial strength filters are available from some manufacturers for specialist applications, such as solar photography and imaging the interior of furnaces and other high temperature processes.

depth-of-field apparent sharpness in front of and behind the exact point of focus; varies with format, aperture and focusing distance
ND filter neutral density filter that reduces light intensity equally across spectrum

ND filter compensation

ND filter		Light transmitted	Increase exposure by
0.1		80%	1/3 stop
0.2		63%	2/3 stop
0.3	ND-2	50%	1 stop
0.4		40%	1 1/3 stops
0.5		32%	1 2/3 stops
0.6	ND-4	25%	2 stops
0.7		20%	2 1/3 stops
0.8		16%	2 2/3 stops
0.9	ND-8	13%	3 stops
1		10%	3 1/3 stops
2		1%	6 2/3 stops
3		0.1%	10 stops
4		0.01%	13 1/3 stops

Hardraw Force in Yorkshire Dales National Park (above)
A neutral density filter cuts down the light entering the camera and permits the use of long shutter speeds, which blurs the falling and cascading water into a misty, milky blur.
Photographer: Rod Edwards.
Technical summary: Mamiya 645 Super, Mamiya 150mm lens with 2x converter, 2 sec at f/11 with mirror lock up Fuji Velvia rated at EI40 for saturated colour not ISO 50, polarizer acting as ND 0.6 filter, cloudy and overcast.

Divine light (above)

Two graduated filters were used in combination to capture this image bringing detail into the sky.

Photographer: Adrian Wilson.

Technical summary: Canon EOS 5D, Canon 24–105 L f/4 IS zoom at 24mm, 2.5 sec at f/22, 2-stop and 3-stop graduated filters (Cokin P121M and P121S) used in combination with a polarizing filter. Contrast and colour saturation adjusted in Photoshop.

Graduated filters

In the context of photographic filters, 'graduated' means a progressive or gradual change from one density (usually clear) or one colour to another. The most useful **graduated filters**, or 'grads' as they are commonly called, are the neutral density sets. These are employed to keep subject brightness range within acceptable limits in the camera and are widely used even with digital cameras, especially by landscape photographers.

A graduated neutral density filter can have two variables. Firstly, how much light the darker section cuts out; secondly, the speed with which the clear changes to the dark. You may find them described as L, M, S (Low density, Medium density or Strong) and Full, or as Soft and Hard, and they will have the usual ND designation (either density 0.3, 0.6, 0.9, etc. or the light loss ND-2, ND-4, ND-8).

The best ND grads are those made of resin, supplied as squares or rectangles. They are not screwed into the lens but fit slots in a holder that itself is fitted on to the lens. The filters and the filter holder can then be adjusted, not only to put the graduation strip into the correct part of the scene, but also by rotating the filter to accommodate hillsides or any time the composition puts the horizon on the slant. From this point of view circular glass graduated filters are very restricted in their use.

Coloured graduated filters have their uses but their application needs to be subtle; the graduated brown (tobacco) filter has been so overused in advertising images that incorporate landscape as to become a cliché. Sepia, yellow and pure blue grads can help the landscape photographer differentiate foregrounds and skies.

Unlike glass filters, grads are not coated to reduce reflections and saturation-killing flare, so they are best carefully shaded when in use to avoid unwanted reflections on their large flat surfaces. It is no coincidence that the manufacturer of the best grad filters also makes one of the best bellows shades.

No graduated filter | Low density | Medium density | Strong

graduated filter (grad) partly toned resin or plastics filter with slightly more than half of the filter clear. Clear to toned area has a smooth transition. Used to darken skies or control contrast

High-key and low-key images

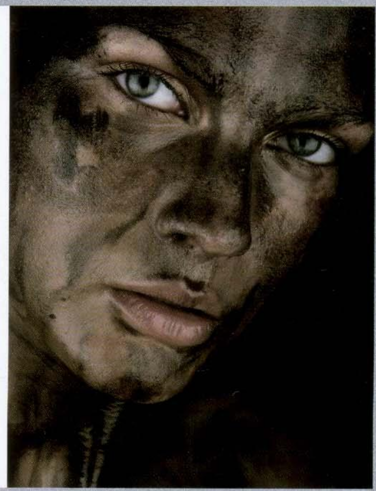
High-key images should not be confused with overexposed images. A true high-key composition will show a full tonal range from black to white, but lighter tones will dominate. Overexposed images will not have any dark tones.

Some subjects – children in particular – are traditionally given the high-key look. It is important to understand both subject brightness range and the way light meters work to successfully light and meter a quality high-key image. It is easy to overexpose the image or accidentally blow out highlight detail. A decision must be taken as to whether a tone will be shown in the brightest 'whites' or whether the white will be intentionally 'blown out', allowing the printing paper to show through in these areas. Studio high-key images invariably use white backgrounds and plenty of even light is required on the background material to create the effect. To get an even-lit background, the lights must illuminate the opposite sides of the backing material from where they stand.

When metering a high-key subject, either use a hand-held incident light meter or use substitute metering from a standard grey card. Following the exposure recommended by a reflected light meter reading without using EV compensation would produce a mid-grey rather than a white image. With a digital camera, the histogram display becomes your guide – a high-key image will show a distribution towards the right of the display with the bulk of the histogram being above the central mid-grey point, but without clipping at the far right white point. Conversely, the low-key image will show a dark weighted histogram all below mid-grey, but with no clipping at the black point.

Low-key images have a serious and darker feel to them, literally and metaphorically. There are two ways to go about creating the low-key look. A composition with only dark items, when correctly exposed, will produce a low-key image. Alternatively, lighting can be used. A scene with a normal range of tones can be lit selectively, using the deep shadows formed to produce a low-key look. In the studio, non-reflecting black material (black velvet cloth rather than black paper, which can reflect a lot of light from its surface) and high contrast lighting achieve this low-key look. Simply underexposing a normal scene will not result in a low-key image, as there will be no highlights at all.

The difficulty with the low-key look is to keep sufficient shadow detail. Again, the incident light meter will help establish an accurate exposure; if a reflected meter reading is used without additional EV compensation the resulting image will look grey and washed out.

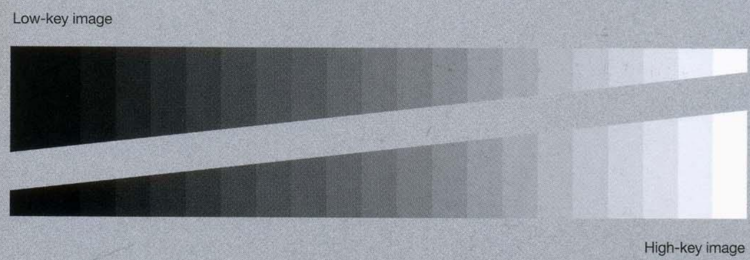


Beauty 32 (above left)/Beauty 31 (above right)

High-key and low-key fashion images, both contain a full tonal range but are biased towards light tones or dark tones respectively.

Photographer: Stéphane Bourson.

Technical summary: (both) Canon D60, ISO 100 (32) Canon 100mm f/2.8 Macro EF, 1/200 sec at f/16. Flash on background, two reflectors on model, one flash head with beauty dish higher on the face and one spotlight with diffuser lower. (31) Sigma 28–70mm f/2.8 EX DF at 70mm, 1/125 at f/16. Two Profoto flash heads with softboxes at 45° to each side of the model. Make-up: Magalie Fockeu.



Polarized light

Unlike other filters, **polarizers** affect the physical characteristics of light, not its colour. Light from the sun spreads in waves in all directions, but lightwaves reflecting off a smooth surface tend to be oriented in the plane of that surface. The polarizing filter has a molecular or crystalline structure that lets light through at one angle, but not another, and can be rotated to block most of the reflected light. Colours will be more saturated and reflections from metallic or water surfaces eliminated or reduced, but the polarizer must be orientated correctly to work and the sun must be shining.

Polarizing filters are neutral in colour. As well as getting rid of unwanted reflections, they have some effect on contrast and colour saturation, working equally well with colour, black-and-white film or digital. Polarizers are useful beyond just darkening skies and getting rid of reflections in glass windows. They can change the reflections from water and show the colours beneath shallow waters. Using a polarizer on brightly lit foliage can increase the colour saturation by reducing the effect of unwanted reflections. Similarly, they can greatly improve the colour rendition of brightly lit rock faces.

Outdoors, the area of blue sky at right angles to the sun can be darkened by a polarizing filter – wide-angle lenses show this effect as a distinct, darkened band in the sky, which can look unnatural. This explains why the advice when using polarizers is to have the 'sun on your shoulder'. Their effect is most noticeable at an angle of 90° to the sun.

Linear polarizers are for use with large and **medium format** cameras, manual viewfinder/rangefinder and SLR cameras without meters. Circular polarizers (C-Pol) are the only polarizing filters that work with modern cameras having TTL meters and auto focus, though they are more expensive to buy than simple linear filters. Camera TTL meters will make adjustments for the light loss that occurs with polarizing filters, but with an incident light meter you must follow the filter manufacturer's instructions and give an extra 1⅓ to 1½ stops exposure to compensate for the light loss.

Some photographers use polarizers in combination with other filters, like 81 series warm-up filters for colour, or with red filters for truly dramatic skies with black-and-white film.

Daylight

In everyday speech, we use the word 'daylight' very loosely. However, it has a very special meaning in photography. **Daylight** film, or daylight white balance on a digital camera, is a closely defined quality of light. Photographic daylight has a colour temperature of 5500K. This was the choice of film manufacturers for colour film to be exposed roughly between 10 a.m. in the morning and 4 p.m. in the afternoon to give acceptably neutral whites.

Photographic daylight is based closely on the measurements of mean noon sunlight (5400K), which is an average of sunlight, measured at 12 noon in Washington, DC every day between the summer and winter solstices. This was chosen as a standard because these measurements had already been taken by the US National Bureau of Standards.

Daylight is not the same as sunlight as it is a combination of direct light from the sun, from the sky (**skylight**) and reflected light from the clouds. A cloudy overcast day, when the sun is not shining, is much bluer than many people think. It is worth remembering that any light that falls into the shadows of an image are illuminated by the skylight alone, which has a far higher (bluer) colour temperature than sunlight. This is one of the reasons a digital camera will have a specific colour temperature setting for 'shade', as well as 'daylight' and 'cloudy' settings.

The quality of daylight can be dependent on the prevailing weather conditions. Conditions that many amateurs would probably reject as unsuitable for photography can produce very satisfying lighting.

It is possible to predict where the sun will rise and set at any time of year and to work out how high it will rise in the sky and at what time. The simplest solution is a pocket **sun compass**. Once aligned, this shows the direction of the rising and setting sun for each month (greater precision is rarely needed). A second scale shows the maximum height the sun will reach in the sky in any given month. Using this to sight on a hill, for instance, will tell you if the sun will clear that particular feature.

The use of **sun tables** is more the province of architectural than landscape photographers. These tables show in detail the exact progression of the sun through the sky, where it will rise and set, and what elevation it will reach at any time of the day. Architectural shots can therefore be planned down meticulously to the month and time of day when a certain building will be lit in a particular way.

daylight average summer sunlight as measured at noon in Washington, DC, USA corresponding to a colour temperature of 5500K
skylight light of blue quality reflected from atmosphere; mixed with direct sunlight and reflected light from clouds it gives daylight
sun compass magnetic compass marked to show where the sun will rise and set at any time of the year
sun tables published charts that give the direction and elevation of the sun at any time of day throughout the year. Especially useful for architectural photography

Early morning deer (above)

An image composed entirely from the palette colours of morning sunshine yellow and gold. Low-angled back light has produced silhouettes from foreground objects while the mist has simplified background detail and made visible fingers of light through the trees.

Photographer: Andy Flowerday.

Technical summary: Pentax Z1-P, Sigma 70–300 zoom, Fuji Velvia ISO 50.

Morning light

The time immediately before and after sunrise is a magical time for photographers. Before the sun rises, the light is richly red towards the rising sun and deep violet blue away from it. Immediately before the sun rises, this light will become pinker, only becoming golden yellow as the sun breaks over the horizon. When there is a mist on the ground, before the sun's heat has burned it off, it is possible to point the camera straight into the rising sun. Light is dramatically scattered, which reduces detail while emphasising shape. Silhouettes created in this way cast eerie shadows towards the photographer through the mist because of the strong backlighting.

Low sun demands respectful handling. Lenses must be carefully shaded if flare is to be avoided and colours kept saturated. Nevertheless, even flare can be used creatively. Bursts of light from reflections inside the lens become the symbolic equivalence in the final image of a viewer having to screw up his or her eyes against the sun. Zoom lenses will show the greatest flare and internal reflections; simply constructed prime lenses the least.

Photographers who take their opportunities early in the morning will be able to produce good images on more days than the average, as days that later turn to rain frequently dawn clearly. The early rising photographer is often rewarded with a stillness, light and colours not often experienced by the majority of people.

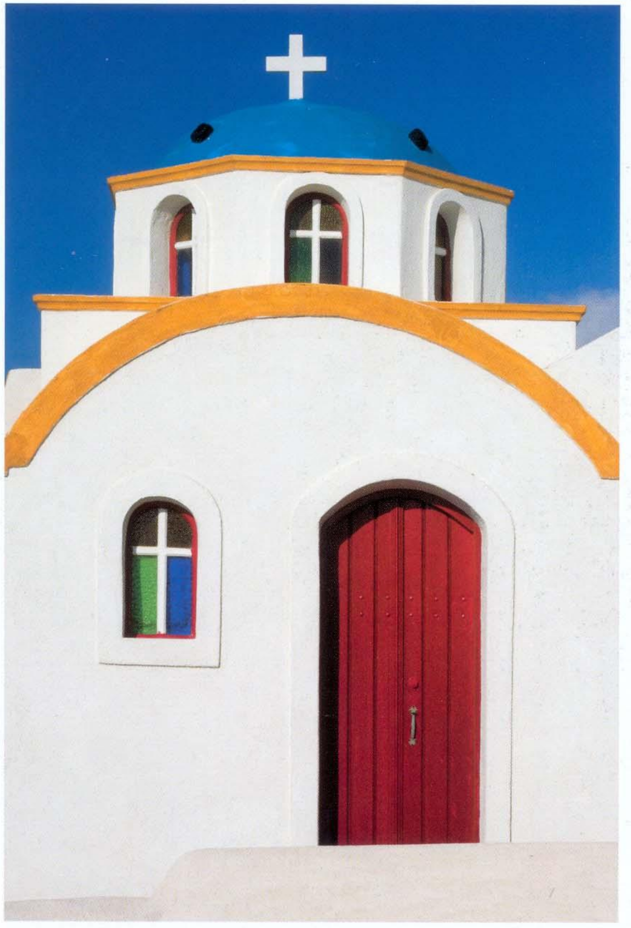
Noon light

Noon summer sunlight, when the sun is at its highest point in the sky, is often considered too harsh for photography, though it is in this kind of light that many amateur snapshots are taken. Sunlight high in the sky may produce unattractive shadows below the eyes and cause squinting, though it does give saturated colours. The biggest problem is that overhead light gives little or no modelling on landscape features and, as mentioned, produces ugly shadows on faces.

The solution for fashion or portrait photographers is to use all the available noon light but shape it for photographic ends using reflectors and cutters; more details of using these items can be found in the chapter on Controlling Light. Scrim can break up harsh light. The simplest to use outdoors – given a wind-free day or plenty of assistants – are large white polystyrene flats as reflectors, which can be painted matt black for use as cutters or black bounces. There is a wide range of commercial reflectors and scrims available – probably the best known being the lightweight California Sunbounce system with 2-metre square reflectors light enough to be held by one assistant. For portraits and fashion photography using overhead noon lighting it becomes almost essential to use a reflector parallel with the ground to throw light back up into the shadows.

Without shadows, landscape forms are not revealed and, though well lit, noontime landscapes shot in summer can look flat and lifeless. However, in winter the noonday sun will barely rise 25° above the horizon (at a latitude of 50°N (London)). It will reach higher elevations the further south you go. Winter noon light will model landscape features well and has a warmer colour balance than photographic daylight, making warm-up filters redundant and the resulting images particularly attractive.

Fashion shoot with reflectors
Two reflectors on stands with a diffuser above the model to break up direct sun from overhead; black bounce behind will emphasise the effect of the reflectors. Scrim to the right of the model. Note the small shadows directly beneath objects showing how high the sun was in the sky.



Noonday church (above)
Near overhead sun produces strongly saturated colours on this painted church near Oia on the Greek island of Santorini. Note the shallow shadows beneath the arch.

Photographer: Rod Edwards.

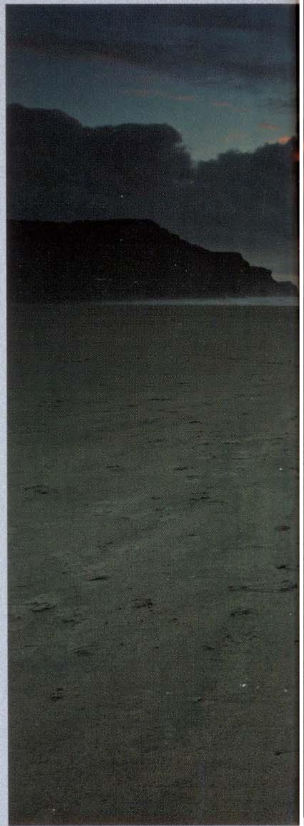
Technical summary: Nikon D2X, Nikon 28–105mm f/3.5–4.5 zoom at 55mm 1/80 sec at f/11, ISO 100.

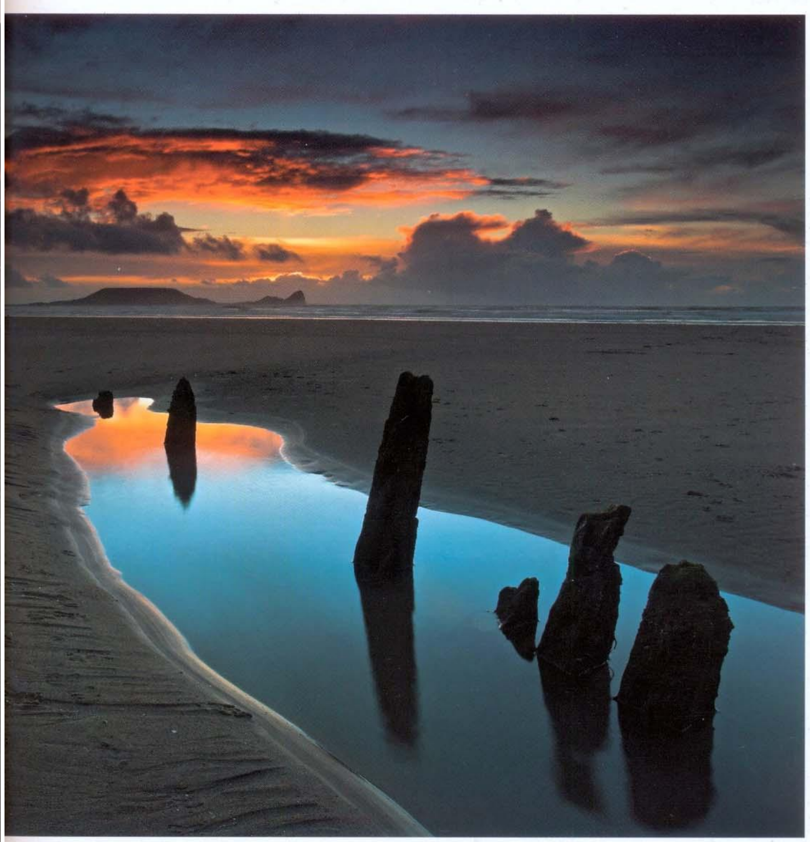
Evening light

From mid-afternoon onwards the morning's progression of light is reversed. Colour is not the only attribute of evening light as it is still apparent in a black-and-white photograph taken during the evening. We judge evening light by the lower power of the sun and the length of shadows it casts. While morning light is seen as soft and diffuse, evening light is a stronger, low-angled source that casts long shadows. Now that all morning mists will have long been burned off, images will be crisper.

Sunsets are possibly the most photographed of all subjects. The rich red and gold evening colours never fail to please the eye and often tap into deeper emotions. Early digital cameras did not have a good track record with sunsets, as they would 'correct' the white balance, reducing the richness of reds and yellows. Some digital compact cameras now feature 'sunset' modes to add these colours to even mediocre sunsets because these kinds of images are so popular.

It is possible on hazy days to include the orb of the sun as a golden-red disk seen through the atmosphere. A very long telephoto lens will be needed to make the disk large enough in the frame. As with all photography where the sun is included, you must be careful of your eyes when looking through a camera pointed anywhere near the sun.





Remains of the day (above)

Wreck of the ship *Helvetia* in Rhossili Bay, Gower Peninsula, South Wales. Careful choice of camera position gets the red sunset clouds reflected in the water pool as well as the brighter blues of the overhead sky.

Photographer: Adam Burton.

Technical summary: Canon 5D, Canon 17–40L, ISO 50.

Night

The darkness of night can be both a security and source of fear. It is how light is introduced to illuminate the darkness that creates one feeling or another. At night, our light sources can swing around to illuminate the unexpected, which sometimes startles us. Torches and car headlights are commonly used in the cinema to create suspense before some secret or horror is revealed. The photographer too can use this pooling of light and darkness by carefully controlling a simple light source – possibly making the light cone visible with mist or smoke – while allowing deep shadows to hint at what may or may not be there.

Night also offers an inky black or softly coloured backdrop depending on the degree of light pollution. The cover of darkness is an ideal time to open the camera shutter and paint a subject with light from a torch or flash; this idea is covered in the last chapter, Using Light. Night is very rarely without some light; the three quarters or full moon is a surprisingly bright reflector of sunlight. This can illuminate cloud and produce an eerie light that – given enough exposure – can make moonlit landscape images look as if they were lit by soft daylight.

At night, readings from a sensitive hand-held light meter need to be interpreted carefully as they will give an exposure to produce mid-grey. Modern multi-segment camera meters make an excellent job of metering difficult night time images; the histogram should be below the centre line, accurately depicting the darkness. Use EV compensation if the camera has a tendency to overexpose dark subjects.

Tripods – light extenders

Photographers sometimes jokingly refer to their 'light extender', by which they mean tripod or other camera support. Available light photographers, looking to get a sharp image in low-level light, will lean to support themselves. Better still is to hold the camera itself against a firm surface like a table or wall – a thin piece of plastic can be used to protect the camera.

Best of all is the tripod. Though sometimes inconvenient for photographers on the move, a good tripod can guarantee an image when it would not otherwise be possible. A 'good' tripod is not necessarily a heavy tripod but a solid one with an easy-to-use head and preferably a quick-release plate for convenience. Choose a tripod you can carry (carbon fibre or other lightweight but strong construction), as this will encourage you to take it with you and use it. Three 'rules' govern the correct use of a tripod: 'one leg under the lens'; 'thick before thin' (leg extensions) and use the centre column only as a last resort. Think 'health and safety' before using a tripod in a public place.

A cable release, wired switch or remote is used to fire the shutter without shaking the camera. The self-timer can be used to trigger a camera if you don't have a cable release – just as long as you don't need to time a shot. If the camera has mirror lock up and it is possible to use it, do so.

Polar star trail (above)

Classic star trail photograph taken in Kings Canyon National Park, California, USA by pointing the camera at the Pole Star around which the sky appears to turn. Final image combines a long exposure by moonlight with a daylight exposure made the next morning.

Photographer: Kit Courter.

Technical summary: Zone VI Studios 5x4 wooden field camera, Schneider 90mm f/8 Super Angulon, main image Provia 100F 3.5-hour at f/8, daylight image made on black-and-white negative film was intended to put some texture into the deep shadow areas of the moonlight image. The two film images were both scanned with an Epson 4870 and combined in Photoshop. The colour image was used as the background with the black-and-white image – given a slight blue tint – as a Layer with 15% opacity and Overlay blending mode.