An Introduction to Photography

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1. Introduction to Photography

It isn't until you delve into photography as a hobby or profession that you realise its complexities and its possibilities. It can be frustrating and rewarding in equal measure so patience and persistence are keywords. The main objective of local camera clubs is to promote photography as a hobby. This includes assisting members to learn and develop their photographic skills, arrange field-trips, guest speakers and competitions, so club membership is recommended. The photographer should be aware that creating great images is an art and operating a camera is a science. Photography requires both skills, in equal measure, to create great images. Creating great photographs is not only about operating a camera, it is art. Great photographs can be created with any camera, even a mobile phone, so it need not be expensive.

This document is called an 'introduction' because it serves as a foundation for the novice and offers direction for students of photography to bring everyone up to the same basic level of competence. Therefore, hopefully, avoiding many of the frustrations whilst enabling students to achieve success in photography, be it a career or in competitions which form the basis for much of a local camera club activities.

It could be argued that learning photography is as complex as learning to drive a car. It requires a combination of study and practice. Over time and with plenty of practice the various aspects of photography can become second-nature thus not requiring conscious concentration – it becomes automatic. This 'introduction' is intended to be a 'drivers handbook' for those wishing to learn how to drive a camera and to achieve good 'pictorial effect' in their photographs. Similar to taking a car driving test, there are various tests of photographic skill to aim for, such as the distinctions offered by the Royal Photographic Society (RPS) and the Photographic Alliance of Great Britain (PAGB) etc.

Because this is an introductory document it is deliberately camera-technology agnostic. However, it does, through necessity, explain some generic camera features to help the student photographer avoid some of the potential pitfalls associated with modern camera use. It is also intended to contain a little more technical depth than what one may get from watching a 'fundamentals of photography' video tutorial online. The written word allows the student to read and re-read a passage and progress at one's own pace rather than the pace of the video tutorial.

The photography student is encouraged to use their local library to borrow books and gain access to online video tutorials on photography and art. Also, to visit galleries to see the work of famous photographers and artists for inspiration. Internet research serves as an excellent source of information from reputable sources such as Tate online, Wikipedia etc. To this end, this 'introduction' document contains links to a few relevant websites to enable the student to do further study for self-learning.

The next few chapters explain the main camera controls for a manually operated camera. Later in this document there is a description of and discussion about the automatic modes available on modern cameras. Also, there is a guide on when to use each mode.

A timeline outlining the evolution of photography and visual art is given as an annex.

2. Aperture

Cameras use a small hole, called an aperture, to control the amount of light reaching the image sensor. The sensor is either electronic (semiconductor) or chemical-based (film). The size of the aperture is one variable (of many) which the photographer has control over. The photographer needs to know the effects of different aperture sizes (aperture settings), thus be able to choose the one which gives the desired effect. The earliest form of camera had a small hole which controlled light and directed it into a wall. The resultant projected image is inverted because a small hole controls the direction of light in such a way as to invert it.

A large aperture lets in more light than a small aperture. This is obvious and logical. However, it also affects something called '**depth of field**'. Depth of field is the name used to describe the area and distance which is in focus hence appears sharp in a photograph. An object too close to the camera will be out of focus and something in the distance will be out of focus when the depth of field is finite. Between these extremes there is a range, a three-dimensional zone, which is in focus. This range which is in focus is called the 'depth of field'. The following photo of an oak bush cricket shows a very shallow depth of field:

If the aperture is large, the depth of field is small. If the aperture is small, the depth of field is large.

Note that the aperture is not the only variable that affects depth of field. The focal length of the lens is also a major factor in determining or controlling the depth of field.

Cameras with a small sensor use lenses that are scaled-down so they tend to give a larger depth of field. Cameras with small sensors are useful because the camera and lenses are smaller, lighter and cheaper. Modern technology allows a small sensor to give good clarity and image quality.

Using a long focal length telephoto lens or zoom lens tends to give the impression objects in the distance are closer to each other, where as a short focal length lens gives the impression there is a big separation between near and far objects. This is mainly due to the fact the long lens has a narrower angle of view. This is described on more detail below.

This feature can be used to achieve good pictorial effect because it mimics natural human vision. When a person looks at an object they naturally focus on that object. Other objects, particularly around the periphery of vision are not seen as clearly. The human eye adjusts quickly and without the person being aware most of the time.

The photographer can use depth of field to good pictorial effect by bringing emphasis to the desired object or intended viewing area and allowing the other areas of the picture to become out of focus thus less emphasised and less distracting. Therefore, control of the aperture is necessary to capture an image which is natural and representative of human vision and fulfils the objective of the photographer.

There is arguably an exception to this goal. That is for technical or scientific purposes. When art and pictorial effect is not the goal of the photographer and a photographic record is the requirement, the goal may be to get the entire image in focus all the way to the edges. Again, depth of field is important because the intent is to avoid any areas being out of focus.

Camera terminology uses the abbreviation **A** or **Av** to represent **aperture** or **aperture value**. The camera aperture value is the area of the hole which allows light through to the sensor. The aperture is usually a circle or approximate circle formed by a diaphragm so the mathematical formula for the area of a circle applies to the aperture i.e. πr^2

Since approx. 1949 cameras have their aperture settings marked with a standard set of values, namely:-

f2.8, f4, f5.6, f8, f11, f16 etc.

The f-number is the ratio of the focal length of the lens to the aperture diameter so it is usually prefixed with the letter 'f', which is an abbreviation for focal length. This is explained in more detail below.

These standard aperture settings make life simple for the photographer because a change of aperture by one setting (known as a '**stop**') from f2.8 to f4 reduces the amount of light reaching the sensor by a half. So, changing the aperture '**A**' by two-stops from f4 to f8 results in a quartering of the light entering the camera i.e. half of a half is a quarter. Similarly, changing the aperture from f8 to f5.6 will double the amount of light entering the camera.

f8 is a typical mid-range setting and the photographer can choose to open the aperture more by changing to f5.6 or f4 etc, or to close the aperture more by changing to f11 or f16.
f8 allows a fair amount of light into the camera, suitable for typical cloudy days, and gives a reasonably useful depth of field.

- **Opening the aperture to f5.6 or f4 etc reduces the depth of field.**
- **Closing the aperture to f11 or f16 increases the depth of field.**

For self-study the photography student could research the Sunny 16 rule

Beware that most cameras now provide 1/3 f-stop increments so moving from f2.8 to f4 requires three clicks on the aperture control.

3. Shutter

Cameras have a mechanism called a shutter which is used to further control the light reaching the sensor. In the early days of photography the camera operator manually removed and replaced the lens cap as a way to control the time the light entered the camera. This was replaced with a manually actuated shutter mechanism where the camera operator decides how long to keep the shutter open for. This was originally a rubber ‘bulb’ which, when squeezed, inflated a smaller bulb in the camera, via a tube, which pushed a lever which opened the shutter then closed it when the bulb was released. A modern shutter can be either a mechanical shutter with moving parts or it can be an electronic shutter with no moving parts so completely silent. Some cameras may have both a mechanical shutter and an electronic shutter. Each shutter type has its merits and limitations. An electronic shutter is better for fast shutter speeds. A mechanical shutter is better for slow shutter speeds, for use with flash and it is better under certain flickering lighting conditions.

In addition to the aperture affecting the amount of light reaching the sensor, the time the sensor is exposed to the light is significant; this is the purpose of the shutter. The shutter is like a door (mechanical shutter) or an on/off switch (electronic shutter). When the shutter is ‘open’ or ‘on’ the light can pass through the shutter to the sensor, and when it is ‘closed’ or ‘off’ the sensor has no light.

The camera’s shutter controls the time that light is allowed to hit the sensor. Cameras typically cater for shutter times between 30 seconds and 1/4000 second or 1/8000 second. This range is sufficient for most purposes.

The following image was taken with a shutter time of 15 seconds causing the milky effect in the moving water:

Some high-end cameras have shutter settings that go up to 1/32000 second. The following photo of a scrambler in mid-air was taken at 1/32000 sec. You can see there is no blurring or sign of movement, especially on the wheels:

Modern cameras may also allow manual control of the shutter's open time. This is known as '**bulb**' mode '**B**'. i.e. the shutter is open for as long as the photographer holds the shutter button down. As mentioned above, in the Victorian era the shutter was operated by a rubber bulb squeezed by hand, hence the name.

If the object to be photographed is moving (or the camera is moving, or both) and the photographer wants to capture it clearly the shutter has to be open for a very short time. This is called a 'fast' shutter speed, such as 1/1000 second or faster.

A median shutter speed is 1/100 second. See the Sunny 16 rule for guidance.

Longer/slower shutter times such as 1/80 sec or 1/25 sec are needed if there is less light. A faster shutter speed, typically 1/1000 sec, is needed if there is a lot of light or the object to be photographed is moving, such as wildlife.

Cameras have their shutter settings marked with a standard set of values, namely:-

1/4, 1/8, 1/15, 1/30, 1/60, 1/125, 1/250, 1/500, 1/1000 sec etc

Each value is approximately half the value of that on the left in this sequence. i.e. twice as fast. Halving the shutter time will allow half the light through to the sensor. These settings are known as shutter '**stops**'. A change of one stop faster will halve the light, conversely a change of one stop slower will double the light hitting the sensor.

Beware that modern cameras often provide 1/3 shutter-stop increments so three clicks are needed to make a one-stop change.

The diligent photography student will realise that there is likely to be an inter-dependence between aperture and shutter speed. Indeed, there is. The photographer can double the light hitting the sensor by either opening the aperture one 'stop' or slowing the shutter by one 'stop'. The term 'stop' is used for the aperture settings and the shutter settings because a 'stop' means a halving or a doubling of the light reaching the sensor or film. Becoming familiar with the term 'stop' simplifies things for the photographer so it is worth fully understanding the concept.

If the object to be photographed is moving or the camera is moving, the result is likely to be the same – a blurred image. This can be overcome by using a fast shutter speed. Unintentionally moving the camera whilst taking a photograph is called '**camera shake**'. Unless done deliberately for artistic effect, camera shake is undesirable and needs to be minimised or eliminated. Resting the camera on something solid or mounting it on a tripod will help eliminate camera shake. Another way to overcome the problem of a moving object is to move the camera at the same speed and direction the object is moving – this is known as 'panning'. A shutter speed of 1/30 sec to 1/50 sec is a suggested starting point for panning. The result of panning is that the object will be sharp but the background will be blurred because it isn't moving with the camera and object. This can be used to achieve a good pictorial effect if done intentionally. It takes practice to do it well.

Modern cameras may have a feature called in-camera-stabilisation (ICS). Some lenses have a feature called optical stabilisation system (OSS). This is technology to help eliminate the effects of camera shake. However, beware of in-camera-stabilisation because it can cause more problems than it solves. As a 'rule of thumb' if the camera is hand-held the ICS and/or OSS can be turned on, but when the camera is on a tripod ICS and OSS should both be turned off. This may appear counter-intuitive. ICS may cause blurring when the camera is not moving because the camera is trying to compensate for movement that doesn't exist. This is normally mentioned in the small-print of the camera's user manual. ICS and OSS can work together to give stabilisation equivalent to a 4 or 5 stop faster shutter speed. This means a slower shutter speed can be used (or lower ISO setting) for darker environments when hand-holding the camera. These stabilisation systems are most helpful when shooting video – more than when taking 'still' photographs.

A novice (and sometimes not so novice) photographer is likely to move the camera slightly when the shutter button is pressed. This is a common cause of camera shake which becomes noticeable with slower shutter speeds and/or long lenses. As mentioned above, using a tripod or resting the camera on a solid surface can help eliminate camera movement when the shutter is pressed. Alternatively, using an in-camera timer or mechanical cable or wired or wireless shutter release system can eliminate the need to touch the camera to operate the shutter. These are all useful techniques to ensure the camera does not move when operating the shutter. The student photographer should practice these techniques for avoiding camera shake. As a 'rule of thumb' when taking 'still' photographs it is suggested the shutter speed be at least the reciprocal of the focal length of the lens in order to eliminate camera shake e.g. When using a 500mm lens on a hand-held full-frame camera (without image stabilisation) the shutter speed should be faster than 1/500 sec to eliminate camera shake.

Camera terminology uses the abbreviation **S** to represent **shutter**. In some documents you may see the abbreviation **T** or **Tv** used to represent the shutter **time** or **time-value**.

4. Lens

A camera usually has a lens that magnifies the light before it hits the sensor or film. A lens with a fixed amount of magnification is called a prime lens. Some camera lenses provide variable amounts of optical magnification, known as a zoom lens. The magnification is related to the '**focal length**' of the lens. The greater the focal length the greater the magnification. A zoom lens has adjustable focal length. A prime lens may provide a wider aperture and less distortion than a zoom lens, as well as being cheaper. The down-side is that it becomes necessary to change the lens more often.

This optical magnification unfortunately magnifies any camera shake. As mentioned above, to minimise camera shake on a full-frame camera the shutter speed should be the reciprocal of the focal length of the lens. Therefore, if a long lens is used either the camera or lens, whichever is the heaviest, should be supported on something solid or mounted on a tripod. A small bean bag is a useful item to rest a large lens on.

As mentioned above, the focal length of the lens also impacts the depth of field. The distance of the camera from the object also affects the depth of field. When using a short focal length lens, also known as a 'wide angle' lens, the depth of field is greater than that of a 'telephoto' lens at a given aperture setting. This feature can be used to achieve good pictorial effect. For example, if the intent is to photograph an object, such as a person, and have the background appear larger and nearer but out of focus, then a telephoto lens should be used. If the desire is to show the object or person and the background all in focus then a wide-angle lens would be better due to its greater depth of field. The photographer may need to stand further away from the object being photographed when using a long lens. The student photographer should experiment with this to become familiar with the effects of **focal length** on **depth of field**, and how these interact with the aperture setting.

The lens normally incorporates the aperture and focusing mechanisms. A lens with automatic focus has a small electric motor which adjusts the lens elements to achieve focus. A lens with manual focus has an adjustment ring on the outside for the operator to control the focus adjustment. There is usually a switch to change between manual-focus and auto-focus modes. Similarly, a small electric motor is used to move the leaves of the aperture to the required f-stop just as the shutter is pressed. Some lenses include an optical stabilisation system which works with the camera to compensate for camera shake. There is usually a switch on the lens to turn this off or on.

A lens designed for a 'full-frame' type of sensor will also work with 35mm film or a sensor which is smaller than full-frame, such as APS-C or DX or micro-four-thirds sensors or 1.0". However, a lens for an APS-C or DX or micro-four-thirds sensor can't be used on camera with a full-frame sensor.

A special type of lens, which has a flatter first element and optimised for shorter minimum focusing distance is called a Macro lens. These are available in a range of focal lengths to give a range of magnification. A macro lens has a different depth of field characteristic compared to a normal lens, for a given focal length. A macro lens is used to photograph small objects and can usually fill the sensor area on a 1:1 or 1:2 ratio with the object being photographed.

5. Depth of Field

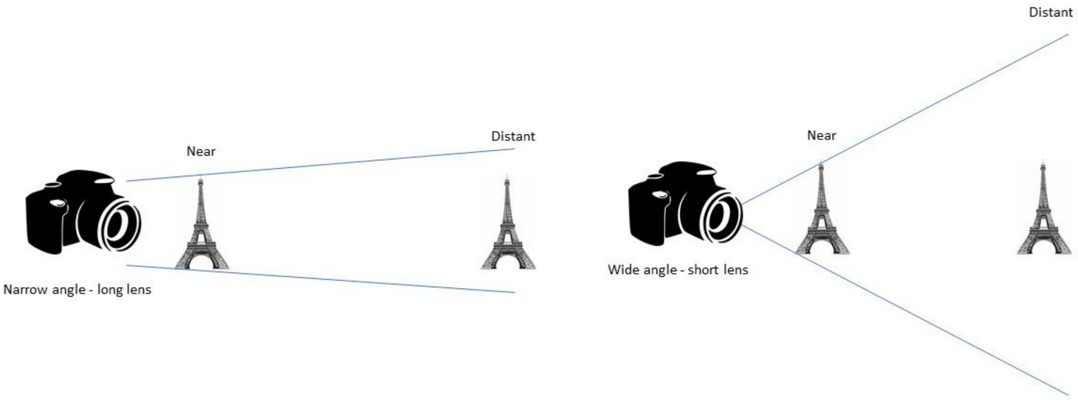
Depth of field was explained briefly above. The depth of field (aka field of focus) is the name given to the range of distance which is in focus. This is determined by a number of variables which includes lens focal length, distance to subject, the acceptable circle of confusion size, and aperture. The diligent student of photography could research the mathematics used to calculate the depth of field if it is of interest. This may be of academic interest but is not too practical when operating a camera. However, a more practical approach is to use a 'depth of field calculator' application either on the internet or as a mobile phone app. By entering details of the camera, focal length and aperture of the lens, and distance to the object being photographed the app gives the distance in front the object and the distance behind the object which are in focus, hence the total range which is in focus.

As a general guide, a short focal length lens such as 28mm gives a greater depth of field than a longer lens with a focal length of, say, 180mm. For a camera with a full-frame sensor and with the object to be photographed 10m from the camera, the depth of field is as follows:-

180mm lens, f22, 10m to subject = 2.8m DoF
180mm lens, f2.8, 10m to subject = 0.34m DoF

28mm lens, f22, 10m to subject = infinity DoF
28mm lens, f2.8, 10m to subject = 30m DoF

The long focal length lens has a narrower viewing angle so the light is travelling more parallel. The short focal length lens has a wider viewing angle so the light is more convergent. The short focal length means objects in the distance appear smaller than objects nearer the camera. The long focal length lens causes objects in the distance to appear nearer because their size appears similar to objects nearer the camera. This can be demonstrated by the following diagram:-



Some DSLR cameras allow the aperture to be closed-down to the current setting to allow the photographer to see (preview) the depth of field through the view-finder. This can be helpful but is not ideal as the amount of light through a small aperture is small making the image seen through the viewfinder quite dark. However, some mirrorless cameras allow a preview showing the effects of depth of field or shutter speed without reducing the amount of light, which was a limitation in DSLRs.

6. Light Sensitivity and Exposure

The light sensor in a camera, be it an electronic sensor in a digital camera or the film in an analogue camera, has a certain amount of light **sensitivity**. The digital sensor or film also has a **dynamic range** which is the range of sensitivities between black (no light detected) and white (full bright light) i.e. the ability to handle a wide range of light intensities. The dynamic range of a camera is less than that of the human eye. Therefore, the best photography is often achieved in soft or diffuse light because that is less likely to exceed the technical limitations of the camera's dynamic range.

As described above, the aperture size and the shutter time both control the amount of light hitting the digital sensor or film.

To allow the photographer to control all aspects of image creation using light, the sensor or film sensitivity, also known as film speed for analogue cameras, needs to be controllable too. Film is marked with an ISO number such as ISO 50, ISO 100, ISO 125, ISO 400 etc. Previously a DIN number (German) or an ASA number (American) was used, but the ISO system is now universally used on film and in digital cameras.

Each time the ISO number doubles, the sensor's sensitivity to light doubles, such that half the amount of light is needed to give a specific brightness in the final image. This is known as an ISO '**stop**'.

Beware that modern digital cameras often provide 1/3 ISO-stop increments so three clicks are needed to make a one-stop change (doubling or halving) in sensitivity. Therefore, modern digital cameras may have ISO settings of:

50, 64, 80, 100, 125, 160, 200, 250, 320, 400, 500, 640, 800, 1000, etc.

As is often the case in life, you seldom get something for nothing. The higher the ISO number the more noise (for digital sensors) or grain (for film) you get on the final image. It is therefore generally desirable to keep the ISO number as low as possible to minimise noise or grain on the final image, but not at the expense of other factors. It is usually necessary to compromise between sensitivity and noise. High sensitivity with high noise vs low sensitivity with low noise is a decision the photographer has to make. As a general guide, indoor photography with digital cameras may need the ISO setting at about 1600 or more and outdoor photography may need the ISO setting at about 800 or less. Depending on the camera make and model, significant amounts of ISO noise is present at approximately ISO 6400 and above. Techniques for removing ISO noise in post processing are discussed below.

The amount of light hitting the sensor or film, together with the sensitivity of the sensor or film, defines the brightness of the image created in the camera. This brightness is sometimes called the '**key**'. This is analogous to a musical 'key' or 'audible frequency'. Light has a frequency and each frequency represents a colour. Black is an absence of light and white represents all the frequencies of light combined. Therefore a 'low key' image is dark and nearer the black end of the light spectrum and a 'high key' image is light and nearer the white end of the spectrum. Note: high frequency visible light is called ultra-violet and low frequency visible light is called infra-red. White light contains all the frequencies from infra-red to ultra-violet, so you can't achieve white or high-key images without including the blues and violet high frequency light.

Digital sensors respond to each colour differently because each colour has a different frequency. A modern digital camera may be able to display a graph (histogram) of the number of illuminated pixels against the light intensity. Such a histogram may also show the red, blue and green primary colours having different intensities i.e. each colour will have a slightly different shape on the histogram graph.

An example of a high-key image:

Camera terminology describes the combination of light hitting the sensor and the sensitivity of the sensor, hence the brightness of the image, as the amount of 'exposure'. Therefore, combining the aperture setting with shutter setting and sensor sensitivity results in an amount of 'exposure'. Too much exposure of the sensor to light results in a white image, too little exposure of the sensor to light results in a black image. Exposing the sensor to light of a specific frequency results in an image of a specific colour, or a range of frequencies result in a range of colours or blended colour. The brightness or intensity of each colour results in the tone of that colour.

The aim of the photographer is to use a camera to capture an image using light with a range of colours, or shades of grey hence light intensities, to create the desired image. The object to be photographed reflects varying amounts of light which allows humans and animals to see it. A camera detects an image on its sensor which represents the light reflected from the object or the light directly from a source. The light is comprised of a range of colours and intensities, which are frequencies and energy levels respectively. Human perception regards 18% grey, averaged over the whole image, as the correct exposure. This is called 'middle gray' because it is what humans perceive as half way between white and black. Photography light meters are calibrated to 18% grey so that they all give the same ISO, shutter, and aperture values for a given exposure value (Ev). This is an important point, so worth emphasising: By standardising the aperture, shutter and ISO values (known as **stops**) on all cameras and all light meters, a light meter will define the settings required on any camera to achieve a given exposure value (Ev).

By combining all the topics described above, photographic terminology uses the term '**Exposure Value**' (**Ev**) to represent the combination of aperture, shutter and ISO settings.

For a given ISO setting (sensor sensitivity), the three variables of Exposure Value, Aperture Value and Time Value can be represented by the following mathematical equation:

Ev = Av + Tv (for a given ISO setting)

This equation tells us that an increase in aperture value **Av** or time value **Tv** will result in a direct increase in exposure value **Ev**, for a given ISO setting. By using the concept of the photographic 'stop' to represent a doubling or halving of light we can say a one-stop change in aperture Av will result in a one-stop change in Ev. Similarly, a one-stop change in shutter Tv will result in a one-stop change in Ev. This is shown by the same Ev value on the diagonals of the following chart:

Table of Ev ‘stop’ values at ISO 100:-

ISO 100	**Av 'stop'**	0	1	2	3	4	5	6	7	8	9	10
Tv 'stop'		f1.0	f1.4	f2.0	f2.8	f4.0	f5.6	f8.0	f11	f16	f22	f32
0	1s	0	1	2	3	4	5	6	7	8	9	10
1	1/2	1	2	3	4	5	6	7	8	9	10	11
2	1/4	2	3	4	5	6	7	8	9	10	11	12
3	1/8	3	4	5	6	7	8	9	10	11	12	13
4	1/15	4	5	6	7	8	9	10	11	12	13	14
5	1/30	5	6	7	8	9	10	11	12	13	14	15
6	1/60	6	7	8	9	10	11	12	13	14	15	16
7	1/125	7	8	9	10	11	12	13	14	15	16	17
8	1/250	8	9	10	11	12	13	14	15	16	17	18
9	1/500	9	10	11	12	13	14	15	16	17	18	19
10	1/1000	10	11	12	13	14	15	16	17	18	19	20

It follows that increasing Av by one-stop and simultaneously reducing Tv by one-stop will result in no change in Ev. This is significant for the photographer because it allows the exposure to be maintained at the required level whilst either changing the aperture value to alter the depth of field or changing the time-value (shutter speed) to capture an image of a fast-moving object.

Sometimes there is not enough light to achieve the required Ev value despite altering the Av or Tv settings available in the camera. The photographer must then alter the light or select a different location with more light or change the ISO value and put up with more noise on the image.

7. Focus

Focus is the sharpness of the image on the sensor. This is seen by the photographer, and measured by a camera, as edges of objects being represented by clear sharp edges. Focus is achieved by altering the position of the lens’ **focal point** with respect to the sensor. The focus setting is directly related to the distance the object is from the camera. See above for an explanation of depth of field.

Modern cameras usually allow for both manual control of the focus setting and automatic focus control. A modern camera can automatically measure focus either by the sharpness of the edges in the image or the phase difference of light frequencies. By using an electric motor in the lens it can alter the position of the focal point to automatically optimise the sharpness of the image on the sensor or film. The camera can then ‘lock-on’ to that focus setting and cease adjusting focus once it has been optimised. It takes time for a camera and lens to achieve focus automatically so the photographer must be mindful of the camera’s auto-focus speed and not operate the shutter until focus is achieved.

Beware that some cameras prevent the shutter being operated if the image is out of focus. If the camera needs time to auto-focus before allowing the shutter to open, this causes shutter-lag, a delay between the photographer’s intent to operate the shutter and the moment the shutter opens. This can cause a photo opportunity to be missed. It is recommended that all photographers understand what Cartier-Bresson meant by the “decisive moment”.

Focusing (manual or automatic) can be difficult in low light conditions or when the object to be photographed does not have any edges or distinct features that allow the camera to lock-on.

Although conceptually quite simple, focusing can be particularly tricky for the novice so it takes both practice and a good understanding of the principles to allow the student photographer to master it.

Focus is particularly difficult when the object to be photographed is moving. Some modern cameras have powerful in-camera computing which can allow the camera to adjust the focus dynamically to track a moving object to maintain focus on it. A technique to capture a moving object in focus is to pre-set the focus to a known location and wait for the moving object to reach that location then operate the shutter at that point. A large depth of field can simplify achieving focus.

As mentioned above, camera shake can cause an image to be blurred so it is sometimes difficult to determine whether a blurred image is caused by camera shake or poor focus. The best approach is to eliminate camera shake, as described above, then concentrate of achieving good focus.

The student photographer should experiment with different focusing techniques and practice it to build the required skills and familiarity with the behaviour of the camera used. With practice it becomes instinctive.

Most modern cameras combine the automatic focus feature with the shutter button, on the theory that you must always focus the camera before operating the shutter. Half-pressing the shutter button normally makes the camera automatically focus on the objects visible. The more experienced photographer may want to separate the focus and shutter controls to allow the camera to be focused at one point in time, then to operate the shutter at a later time without changing the focus. Some modern cameras have configurable buttons on the back panel which allow the photographer to assign the focus function to a dedicated **back-button** rather than to the shutter button. If the camera does not allow the auto-focus function to be assigned to a back button, instead of the shutter, it may allow a back button to turn off auto-focus instead. This allows the photographer to half-press the shutter button to get the auto-focus to lock-on, then to turn off auto-focus to hold that focus setting, so pressing the shutter at a later time will not alter the focus and avoids shutter-lag.

The student photographer should explore and learn what their camera's focusing capabilities and limitations are and work within the camera's limitations. All cameras have limitations, regardless of cost.

The view-finder is where the photographer normally looks to see what the camera sees, in advance of taking the picture. The photographer's eye has to focus on the image in the view-finder. Because human eyesight varies from person to person the camera needs to allow some adjustment of the image in the view-finder. This is known as the '**dioptre setting**' of the view-finder. If the dioptre setting is wrong it will be hard for the photographer to see when the camera is in focus, making manual adjustment of camera focus difficult.

Note: dioptre is the word used to mean the reciprocal of focal length.

Modern digital cameras often have a screen on the back, either instead of or as well as the view-finder. Either the viewfinder or the back-screen can be used to frame the scene to be photographed, or to view the image that has just been captured. Reviewing the image immediately after it is taken is a useful technique to iteratively refine the images until the ideal image is captured – only possible on a digital camera or Polaroid camera. Before digital cameras were used by professional photographers, they used Polaroid film as a way to get a quick 'rough and ready' image to check the lighting, framing, etc., before capturing the final image on expensive film.

The various focus modes in modern cameras and their uses are summarised as follows:-

AF-S is a 'single-shot' focus mode for automatically adjusting and locking-on the focus to a static object e.g. for a portrait. When the camera achieves focus it 'locks-on' and no longer adjusts the focus, which is useful because it allows the photographer to re-frame the image without altering the point of focus.

AF-C is a 'continuous' focus mode for tracking moving objects to keep them in focus e.g. for sports photography. The camera's auto-focus motor constantly adjusts the point of focus to find the optimum focus setting. Note: If the object to be photographed is not moving, the camera will rapidly pulse or flutter the focus resulting in the object being rapidly in and out of focus. If the shutter operates when the focus is sub-optimal, the resultant image will be slightly out of focus, so AF-C should only be used when either the camera or the object to be photographed is moving.

AF-A is an 'automatic' auto-focus mode available on some makes of camera. This mode lets the camera automatically choose between AF-S and AF-C modes. If the camera senses movement of the object being photographed, or senses the camera is moving, it goes into AF-C mode to track the moving object.

DMF is a 'direct manual focus' mode. This allows the camera to rapidly auto-focus first (as for AF-S mode) then allows the photographer to make small manual adjustments to refine the focus before the shutter is pressed.

MF is the 'manual' focus mode which lets the photographer adjust the focus, without any automated adjustments. Some cameras have an 'MF Assist' feature which uses digital zoom to temporarily zoom in to give a close-up view to assist accurate manual focusing.

Eye Focus is an advanced feature where the camera detects eyes and locks the focus onto an eye because this is optimum for portraits. Some cameras can only detect human eyes but some can also detect animal eyes too. i.e. for portraits of people and pets the eyes needs to be in focus. Eye focus mode can be assigned to a custom button on the back of the camera to enable the photographer to choose when this feature is used.

Focus Area is a feature which allows the photographer to choose which part of the image is used for auto-focusing. The options are normally a single central focus spot, an adjustable spot to allow the photographer to move the focus spot to the part of the frame to be used for focusing, and multi-focus which is where the average focus across the entire image is used to get the best average focus. It is often regarded as beneficial to use a centre focus spot with the AF-S mode so the photographer can half-press the shutter when the centre spot is on the object to be in focus, then whilst the shutter is half-pressed re-frame to compose the image then press the shutter down the rest of the way to take the photograph.

Peaking Level and Colour are features to assist manual focusing. The camera detects edges and when the edges are sharp it highlights them in the viewfinder. The highlighting colour can be selected (e.g. red, yellow or white) to give a good contrast to the object being photographed or for user preference.

Pre-AF is a feature to allow the camera to immediately auto-focus itself before the shutter button is pressed. This can be helpful but often causes the camera to focus on things the photographer did not intend to focus on. It can be used to good effect when used in combination with the 'focus hold' or 'focus-lock' mode which allows the photographer to stop the camera changing the focus setting once correct focus has been acquired.

Focus Hold is a feature which allows the photographer to focus on an object then lock the focus to stop focus changing to allow the image to be re-framed.

8. Framing and Cropping

Novice photographers often take photographs too far away from the object being photographed. This is a common mistake for beginners. The result is an image with too much information and inclusion of distractions. Good composition uses the principle of 'unity' i.e. one picture one purpose. If the image is cropped down to the intended object in post-processing the photographer is in effect throwing away (wasting) many pixels which could otherwise be used to improve the image quality. Where possible the photographer should attempt to frame the image so it contains all the required information and nothing else, hence does not need much cropping.

Good pictorial composition is when nothing can be added and nothing can be taken away to make the picture better. Before photography was invented, paintings and drawings were the only way to record images. The principles of good pictorial composition were used by the great masters of painting and evolved over a long period of time.

An image is 'stronger' at drawing the viewer's attention to an object if it only contains that object. However, it is often desirable to show the object in its context thus including the surroundings too. The surrounding can either reinforce the viewer's attention onto the main object or distract the viewer from the main object. To reinforce the viewer's attention onto the main object the surroundings need to be subordinate and not distracting. The great masters of painting, before photography was invented, had mastered composition. Therefore, photographers in the 1800s used art composition as a starting point for good photographic composition.

9. Lighting

Photography is all about using light to capture an image. The photographer must have an understanding of light in its various forms to be successful at capturing great images using a camera.

As mentioned above, if there is insufficient light the image will be dark (under exposed) and if there is too much light the image will be too bright (over exposed). In reality, light is more complex than that. Also, it is not just the light that is important; your position in the available light is critical to success.

Light is a natural phenomenon which is quite well understood by scientists and appreciated by all people and animals with sight. The student photographer should go a little further than having a basic appreciation of light and gain a good understanding of the various types of light, both natural and man-made, and how they can impact the camera's ability to create an image. If there are both bright areas and dark areas in a scene a camera may struggle to capture both of those extremes. A camera, regardless of cost, has a finite limit to its dynamic range. It is best to avoid taking a photograph in the intense sunlight at midday and opt for shooting at sunrise, sunset or during cloudy days or in shadows when the light is soft and diffuse. However, if it is essential to take photographs in bright sunshine there are techniques for achieving that. See the description of flash lighting below.

For the photographer it is helpful to understand the following types of light:-

- **Directional light** = light hitting the object to be photographed from one direction
- **Diffuse light** = light traveling equally in all directions

- **Reflected** or specular light = bright light bouncing off an object
- **Magic light** = a spot of light on the landscape as seen when there is a gap in clouds
- **Twilight** = semi-light at either dawn or dusk
- **Night light** = small areas of bright light in a generally dark environment
- **Window light** = light entering a building through a window or opening such as a doorway
- **Studio light** = one or more sources of artificial light either constant or delivered as a flash
- **Flash light** = one or more sources of artificial light delivered as a flash

Directional light is theoretically able to hit any one of the six sides of a three-dimensional object. The direction may be back, front, left-side, right-side, top or below; or anywhere in between these points. In fact, assuming the object to be photographed is a sphere, directional light could theoretically hit any hemispherical area of the sphere. These types of light may be from either natural sources (e.g. daylight) or from artificial sources (e.g. studio lights). Side-light, back light and top-light are the most commonly used types of directional light in photography. Directional light can result in big differences between the bright areas and shadow areas in a scene so likely to go beyond the camera's dynamic range unless care is taken. Directional light gives strong shadows which can help emphasise the three-dimensional shape of objects.

Diffuse light is the opposite of directional light and has no particular direction, it is omnidirectional. This tends to light an object evenly on all sides simultaneously so it does not tend to create strong shadows. Diffused light occurs naturally on cloudy overcast days or can be derived from artificial sources (e.g. studio lights fitted with a soft-box diffuser). Diffuse light does not usually cause big differences between the bright areas and shadow areas in a scene so unlikely to go beyond the camera's dynamic range.

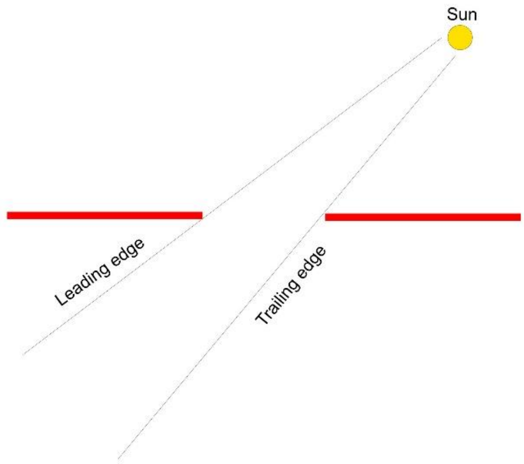
Reflected light can occur naturally or be deliberately reflected using a mirror or white or light coloured material such as cardboard, aluminium foil, bedsheet, etc. This is useful for giving another direction to light that was unidirectional so the photographer can light two or more sides of an object from one light source, thus reducing the dynamic range and reducing the harshness of shadows. However, if light is reflected towards the camera it could result in big differences between the bright areas and shadow areas in a scene which could go beyond the camera's dynamic range unless care is taken or it could cause a bright spot which is distracting in the final image.

Magic light is where the sun shines through a gap in the clouds onto the landscape in a small area. It is light a spotlight and gives a very desirable effect if it is highlighting the main object or focal area of the image.

Twilight occurs naturally at dawn and dusk. It has direction from the horizon so tends to cast long shadows, if bright enough. It also tends to have a colour tint, due to dust or moisture in the atmosphere, giving it an orange, pink, red or yellow warmth which can give a beneficial pictorial effect. Light just before sunrise, or just after sunset tends to be blue in colour because the atmosphere scatters the light and the higher frequency light (blue) gets through and the lower frequency light (red) doesn't. Light in shadows is also slightly blue. Sunrise and sunset are excellent times of day to take outdoor photographs. Natural light and man-made light can be more easily balanced within an image taken at twilight.

Night light is predominantly artificial light, usually from multiple sources, in a wider expanse of darkness but may include light from stars and the moon. This gives photographers a particular challenge for achieving the optimum exposure in the presence of extremes of light and dark. Artificial light can be any colour. Fluorescent light tends to be green and tungsten light is yellow. Some types of light flickers at a high frequency so this could give undesirable effects when it is a harmonic of the shutter speed. Some cameras have anti-flicker technology. Mechanical shutters tend to be less prone to flicker problems than fast electronic shutters.

Window light usually has two edges, the leading edge and the trailing edge. Assuming the light is directional and not at exactly 90 degrees to the window, the leading edge is where the angle between the direction of light and the inside wall is less than 90 degrees (an acute angle). The trailing edge is where the angle between the direction of light and the inside wall is more than 90 degrees (an obtuse angle). See following diagram. The photographer can choose whether to use the stronger light on the leading edge of the window or the softer light on the trailing edge of the window. The nearer the window the object to be photographed is placed, the softer the light.



Studio lighting is a subject for the student photographer to study as a subject in its own right. With multiple artificial light sources, each with controllable intensities and positions and directions, diffusers and reflectors the photographer has full control of the light sources. Even the colours of the lights can be controlled. Studio light can be either on constantly or delivered as a flash. When artificial light is close to the subject it is more diffuse so softer. When artificial light is further from the subject it is more directional so harder (specular).

Flash is a particular form of artificial lighting which can be used in a studio, indoors or outdoors. To control flash lighting the photographer would traditionally use a low ISO setting and small aperture setting to eliminate ambient light then set the flash gun to give as much light as is required to achieve the correct exposure. Some cameras have a flash light built-in. This is convenient but does not give the photographer much control of the light intensity or direction. An off-camera flash gun is more controllable, in terms of position at least. A stand-alone flash gun's output can be measured using a light meter and adjusted manually or automatically by using direct electronic communication between the camera and flash gun to allow the camera to tell the flashgun when it has received enough light. This is called 'through the lens' (**TTL**) control of the flash gun. This automatic control is only achievable when the flash gun and camera are compatible. TTL controls the flash gun to give the required amount of flash lighting to top-up the ambient lighting by the required amount for a correct exposure (called fill flash). If a multi-way cable or wireless transmitter is fitted to the camera, or via optical sensors on the flash guns, it is possible for multiple flash guns to be synchronised to light the object to be photographed from multiple directions simultaneously. Synchronising the flash from the flash gun with the shutter is an important aspect of flash photography and requires some study. If the shutter speed and flash speed and timing are not compatible some undesirable effects can be seen, such as a black bar across the image. The section below explains flash photography in more detail and the student photographer is encouraged to study it as a topic in its own right.

The above types of light can be used individually or combined to create the lighting effects desired by the photographer, provided the photographer understands the different types of light and how to control them. Light is comprised of a range of colours so when you control the light you also control the colour of the image (or the shades of grey when shooting in black and white mode).

The word **chiaroscuro** (based on the Italian words for light and dark) has been used for centuries to describe the range of light and dark areas of a picture or painting. See chiaroscuro in Wikipedia for a more detailed explanation. Photographers now use this word too. The human eye naturally gravitates to the light or the dark areas of a picture. This can be used by the artist or photographer to achieve good pictorial effect. By ensuring the main object or subject of the picture is well lit and the less important areas of the picture are in the shade, the photographer can lead the viewer to concentrate on the picture in the intended way.

10. Flash Lighting Techniques

Assuming one flash gun and a digital camera in manual (M) mode is used, the photographer would normally use a low ISO setting and small enough aperture to eliminate ambient light (but wide enough aperture to achieve the required depth of field) and a shutter speed as fast as feasible within the 'flash sync speed' ('flash sync speed' is explained below). Taking a test shot without activating the flash is the way to verify the ambient light has been eliminated. Using a medium neutral density (ND) filter such as ND4 can help reduce ambient light when a wide aperture is required to achieve a shallow depth of field. If some ambient light is desirable e.g. to give a lighter background, the settings can be adjusted and a further test shot taken to get the required ambient exposure without flash.

To get the required amount of flash light the flash gun can initially be set to a medium setting such as 1/8th power and a test shot taken. The flash power can then be adjusted up or down as required. Alternatively, if a hand-held light meter is available this can be set to flash activation mode, white dome over the sensor, placed near the object and facing the camera then the flash activated. The light meter will provide the speed and aperture values for a given ISO setting.

If the flash gun and camera are compatible and the flash gun mounted on (or connected to) the camera, it may be possible to use direct electronic communication to allow the camera to tell the flashgun when it has received enough light. This is known as TTL control of the flash gun. The camera has control of exposure provided exposure metering is configured to appropriately measure the flash lighting. The TTL feature is ideal for taking flash shots in a hurry.

The flash sync speed is an important limitation which needs to be understood and carefully managed. Synchronising the flash from the flash gun with the shutter is an important aspect of flash photography. Before the invention of fast Xenon flash tubes a filament lamp was used and a delay was required to allow the lamp to heat up and generate light. Modern cameras allow the flash to be timed to occur just as the shutter is opened or just before the shutter closes. If the shutter timing and flash timing are not compatible some undesirable effects can be seen, such as a black bar across the image. This occurs when the camera has a mechanical shutter and the flash fires whilst the mechanical shutter is partly in front of the sensor. Ideally the shutter should be fully open when the flash fires so the sensor is exposed to all the flash light. Camera manufacturers usually state the camera's 'flash sync speed' (also known as the X-sync speed) which is typically about 1/250 sec on a DSLR or faster on a camera with a leaf shutter rather than a focal plane shutter. The sync speed is the fastest shutter speed that can be used with flash. A focal plane mechanical shutter on a modern camera is often designed to have two curtains which move vertically in front of the sensor in the position called the focal plane. The focal plane is where the light from the lens converges. One shutter curtain will be covering the sensor and one retracted when at rest. When the shutter is activated the curtain covering the sensor moves to reveal the sensor, exposing it to light from the lens, then the other curtain moves to cover the sensor to close the shutter. For slow shutter speeds only one curtain is in front of the sensor at a time. For fast shutter speeds, rather than revealing the entire sensor, as one curtain moves off the sensor to expose it to light the other curtain moves to cover the sensor shortly afterwards. i.e. both curtains are moving. The mechanical shutter therefore presents a 'slot' opening and the slot moves across the sensor. If this is the case, the duration of the flash would need to be long enough to span the time the slot takes to traverse the entire sensor. Flash guns with a 'high speed sync' feature do exactly this, the flash duration is longer, formed by a series of short flashes. If the 'high speed sync' feature is not used with a fast mechanical shutter the image is likely to be dark or have a black region at the top or bottom or both top and bottom. The student photographer must therefore get to know the camera and flash gun's design features and characteristics then make adjustments accordingly to get the desired results.

The flash can usually be configured to occur when the shutter first opens fully (first curtain), or just before the shutter is due to close (second curtain). Fill flash is first curtain flash and the camera uses the flash and/or shutter speed to create a correct exposure depending on the exposure mode selected. The term 'slow sync' flash generally refers to either first curtain flash or second curtain flash where the shutter is slower than the duration of the flash pulse. Front-curtain slow-sync is like fill flash but with the shutter speed adjusted to capture more of the ambient light to help prevent the background being too dark whilst still having the foreground correctly illuminated by the flash. Fill-flash and slow sync flash are similar apart from the camera doing a second light measurement after the flash has fired to measure the ambient light when slow sync is selected. Slow sync is no different to fill-flash when the camera is in manual mode because the camera can't change any parameters to balance the ratio of ambient and flash light. The term 'rear sync' generally refers to second curtain slow-sync. The flash is fired just before the second curtain closes. It is a variant of 'slow sync' so the shutter is set for the ambient light and then the flash fires just before the shutter closes. The result of timing the flash this way is for shooting moving objects to give the image some blurred movement prior to the flash firing then when the flash does fire the main foreground object in the image is sharp due to the quick flash. If the scene is static (no moving objects) then both front-curtain and rear-curtain versions of slow-sync give the same result. When using slow-sync modes (front curtain or rear curtain) it is best to set the camera's light meter to multi-zone metering so the light meter can measure the light across the entire sensor, rather than using spot metering which may not control the foreground and background exposures adequately.

If only one flash gun is available it is possible to light an object from two or more directions by using reflectors. These can be made from crumpled aluminium foil, white card, etc or purpose-made reflectors bought. Alternatively, multiple flash guns can be used to light an object. A typical studio lighting set-up may have four power-adjustable flash lamps with modelling lamps. Modelling lamps provide continuous light when the flash is not active for setting-up the scene and they allow auto-focus to be used prior to flash activation. If four flash guns or studio flash lamps are available, two could be used to illuminate the background to eliminate shadows and the other two can be used to light the object from the front, sides or from above. If flash is used to illuminate the background it should be low-level flash a few 'stops' below the main flash guns used to light the main object.

It can be regarded as normal for one flash lamp pointed towards the object to be the main, the other directed onto the object to be the secondary and the two others used for illuminating the background or back-lighting the object to be tertiary.

Multiple flash guns or studio lamps can be triggered from the camera by either:

a) cables
b) wireless trigger and detectors
c) optically
or a combination of these.

For example, a wireless trigger may be fitted to the camera's hot shoe which sends a wireless signal to a wireless receiver connected to the main flash gun or studio lamp. When that main lamp is activated its flash activates the optical sensors on the other lamps causing them to flash in unison. Alternatively, the first lamp could be connected to the camera via a cable and the other lamps are activated via optical sensors. A similar approach can be used to trigger multiple flash guns if they can all detect the one wireless trigger signal from a transmitter on the camera.

Coloured gels on the flash gun or filters on the camera can be used to achieve a range of tint effects. Using multiple flash guns each with a different coloured gel allows multi-coloured tints to be projected onto the object being photographed. Putting coloured filters on the camera can either give the whole image a coloured tint or it can be used to alter the white-balance and compensate for different types of lighting such as incandescent lamps, fluorescent lamps, xenon lamps, etc.

This could be used instead of using the camera's internal 'white balance' settings (white balance is explained below). As mentioned above, light can be regarded as a wave with a particular frequency. The frequency defines the colour of the light. e.g. Blue and violet light have a higher frequency than yellow and red light. The colour can also be measured using a colour temperature scale in degrees Kelvin (K). Colour and thermal temperature are related. A yellow flame is cooler than a blue flame. A hot blue flame uses more energy and emits higher frequency light. Incandescent lamps (old-style filament light bulbs) have a colour temperature between 2600K and 3000K so appear yellow. A 100 Watt halogen lamp has a colour temperature of 3200K. A fluorescent lamp has a colour temperature of 4000K and may appear to have a slight green tint. A Xenon flash gun has a colour temperature between 5000K and 6000K which is similar to the colour temperature of daylight. Modern LED lamps have their colour temperature stated on the box such that 'warm white' has a lower Kelvin value than a 'cool white' LED lamp. The words 'warm' and 'cool' in this context are used to reflect 'emotion', not actual thermal temperature. This means LED lamps with a high colour temperature described as 'cool white', available from good DIY shops, can be used as photography lamps so long as they do not flicker. It is also possible to buy a ribbon with many small LED lamps on. These can be used to create low-cost circular photographic 'ring lights'.

Modern digital cameras normally have a control called 'white balance'. This control alters the colours in an image to make them nearer to how they look in daylight and whites more white. This gives a good compromise but can cause images to lose some desirable colour tones because it tries to make whites white even if you didn't intend that to happen. White balance alters an image to make it more yellow (warmer looking with a higher colour temperature) or more blue (cooler looking with a lower temperature value). A tungsten filament incandescent lamp gives off a yellow light so images taken in tungsten light may need to have their colour temperature reduced to make them look more blue, equivalent to how they would appear in daylight. White balance can be used to make an image taken in artificial light to appear as if taken in daylight or it can be used to deliberately give a colour tint to an image, if desired. When using flash it is best to select the camera's white balance setting for flash rather than using auto white balance or any other white balance setting, unless done-so knowingly. The main requirement to enable white balance adjustments to work correctly is to not mix colour temperatures in an image. Multiple light sources of different types and colour temperatures will make it hard for the camera to automatically adjust the white balance and be hard for the photographer to adjust the white balance in post-processing.

It is best to use a single light source or multiple lights with the same colour temperature to avoid such difficulties.

The white balance setting could be used to deliberately give a colour cast over an image. The 'tungsten' setting will cause the image to be made more blue in the camera, so you could choose the 'tungsten' setting when shooting icy or snowy scenes to make the snow look more blue, giving a cold impression. Conversely, an image taken in normal daylight or flash can be given a golden warmth by setting the white balance adjustment to the 'shade' or 'cloudy' setting because that setting increases the colour temperature.

Note: When capturing images as RAW files in the camera, the white balance can be fully adjusted in post-processing, so the white balance setting can be largely ignored i.e. just set it to the 'daylight' setting and do any white balance adjustment you require in post processing if shooting in RAW. It is a good idea to not use automatic white balance because that may cause intended colour tones to be lost.

Note: If you are capturing your images in the camera as JPG and not storing them in RAW format you should pay attention to the white-balance setting in your camera because it is harder to adjust white balance of a JPG file during post processing.

11. Exposure Modes

Most modern cameras have the following primary controls:-

- **Auto** – Fully automatic mode
- **P** – Program mode
- **A** – Aperture priority mode
- **S** – Shutter priority mode
- **M** – Manual mode

Auto is the fully automatic mode which is designed to allow the camera to decide the optimal settings. The camera decides the best compromise. This is useful if the intent is to be able to simply point and shoot. As with most things in life, compromise may not achieve what is required or intended by the photographer. For a novice to get their camera off the Auto mode it is necessary to understand the other modes available.

P - Program is a semi-automatic mode where the camera calculates the exposure value **Ev** and offers the user a range of feasible aperture **Av** and shutter **Tv** combinations. This mode allows the user to set the ISO setting then scroll through a limited range of **Av + Tv** values that give the required exposure **Ev**. The user can choose a faster shutter speed with wider aperture hence less depth of field or a slower shutter speed with a greater depth of field. The ISO setting is also under the control of the user so an increased range of feasible **Av + Tv** values can be achieved by the user manually increasing the ISO setting, at the expense of more noise on the final image.

A - Aperture priority mode **(Av)** is where the camera allows the user to manually set the aperture (to control the amount of light entering the camera and to alter the depth of field) and the camera calculates the required shutter speed **Tv** to achieve the required exposure value **Ev**. The ISO setting is also under the control of the user so a faster shutter can be achieved by the user manually increasing the ISO setting, at the expense of more noise on the final image.

S – Shutter priority mode **(Tv)** is where the camera allows the user to manually set the shutter speed (e.g. to capture fast moving objects) and the camera calculates the required aperture **Av** to achieve the required exposure value **Ev**. The ISO setting is also under the control of the user so a smaller aperture can be achieved by the user manually increasing the ISO setting, at the expense of more noise on the final image.

M - Manual mode is where the camera allows the user to manually set everything, including the shutter speed **Tv**, the aperture setting **Av** and the **ISO** setting. This means the photographer has to determine the exposure value **Ev** that will result from the chosen settings to achieve the correct exposure value Ev. Modern camera automatically show the amount of under or over exposure when using the manual mode, based on the camera's built-in light meter. The manual mode gives the photographer full control of the four main variables of Ev, Tv, Av and ISO. This mode is appropriate when the photographer has plenty of time to choose the settings and measure the available light by some means, either using the in-camera light meter or other means such as a separate hand-held light meter. Manual mode is normally used in a photographic studio where the photographer has full control of the lighting and other variables. Therefore, manual mode is not ideal for photographing fast moving objects such as wildlife, unless it is done in fully controlled conditions such as a studio.

So which mode is best?

Photojournalists may have specific business pressures to obtain images quickly and send them back to their newspaper immediately. They tend to have their camera set to capture files in both JPEG and RAW format, or just JPEG, so the JPEG file can be used or sent immediately. They would typically use the **A - Aperture** setting to allow them to control the depth of field and let the camera control the other variables. A flash gun may be used to add more light to the subject hence get a faster shutter speed (fill-flash). The flash gun could be used in TTL mode for further automation and simplification hence reduce the time needed to capture the image. Photojournalists would often need to use a fast shutter or work in dark environments so would choose a high ISO setting and put up with noise, or remove the noise in post processing.

Fine art photographers may also use the **A - Aperture** priority setting to allow them to control the depth of field and they may not worry about the shutter speed because the camera can often be used on a tripod to allow longer shutter times, without camera shake. The fine art photographer would normally want to minimise noise or grain on the image so would choose a low ISO setting.

Wildlife photographers need to capture fast moving objects so would tend to use the **S – Shutter** priority mode and be less concerned about the depth of field but also use a tripod to minimise camera shake which is magnified by using a large telephoto or zoom lens. Wildlife photographers would often need to use a fast shutter or work in dark environments so would choose a high ISO setting and put up with noise, or remove the noise in post processing.

Portrait photographers normally have enough time and control of the lighting to allow them to use the **M – Manual** mode, particularly if the portraits are taken in a studio where lighting, props (such as chair, table, etc) and background are controllable. The portrait photographer would normally want to minimise noise or grain on the image so would choose a low ISO setting.

Therefore, different camera modes suit different situations. This is an important decision for the photographer to make. The student photographer is encouraged to try all the modes and decide which mode they prefer for which situation.

12. Control of Exposure

Exposure and Exposure Value were explained above. The various types of sensor in digital cameras and the various types of photographic film, each have a limitation called 'dynamic range'. The dynamic range is the range of light intensities which can be detected and handled correctly by the camera. The greater the dynamic range the better but all cameras have their limits.

At the lower end of the dynamic range very small amounts of light may not be detectable by the sensor or film such that a small change in light is not detected. This means information is lost due to a lack of sensitivity. Similarly, at the higher end of the dynamic range very large amounts of light may not be detectable by the sensor or film such that a small change in light is not detected.

If film is being used, rather than a digital camera, the photographer should look at the datasheet for the film to see the film manufacturer's guidance on exposure settings and optimisation. For example, some types of film have non-linear sensitivity characteristics such that long exposures of more than one second need to be adjusted so the camera increases the shutter time more than a light meter recommends.

Digital sensors are manufactured using semiconductor materials based on silicon. Sensors are usually one of two types, either Charge Coupled Device (CCD) technology or Complementary Metal Oxide Semiconductor (CMOS) technology. Most camera sensors are now made using CMOS technology because it is more economic to manufacture them in bulk. Modern semiconductor manufacturing techniques can etch a large number of light detector circuits (known as a photo-detector or photo-site) onto a given area of silicon. A photo-detector with an amplifier is known as an active pixel sensor. For example, a digital sensor the same size as a 35mm film frame (36mm x 24mm), known as a 'full frame' sensor, can now have over 60 million active pixel sensors. Each active pixel sensor represents a picture element or 'pixel'. The photo-detector is comprise of an array of light-sensitive diodes, each with either a red, green or blue filter in front of it. This is called a Bayer filter mosaic. The combination of RGB colours can be used to represent any colour. Each pixel is typically represented by 10, 12 or 14 bits (binary digits) of data, depending on the camera design. 10 bits give 1024 different values, 12 bits give 4096 different values, 14 bits give 16384 values. It follows that cameras which represent each pixel with 14 bits of data have the ability to more accurately represent the pixel data than one using 10 or 12 bits. The bits of data must also represent the colours so the more bits per pixel the more accurate the representation can be. If too few bits are used to represent the pixel data it can result in something called 'banding' on the final image. This is where a continually gradated colour is represented with edges or steps between each shade, hence bands of colour rather than a smooth gradation. When the camera compresses an image it reduces the number of bits used to represent each pixel, so the highest quality image is achieved by using an uncompressed RAW format.

The physical size of each photo-detector has a significant influence on its dynamic range and noise performance. If all other design factors are equivalent, the larger each photo-detector is the better the dynamic range and the lower the noise. However, there are other techniques camera manufacturers can use to improve the dynamic range of a given size of sensor, such as stacked sensors, back-illuminated sensors, etc. For a given sensor size there is usually a trade-off between the number of pixels and the dynamic range and noise performance. Camera manufacturers may offer cameras with a lower pixel count but faster performance as well as offering a high pixel count camera with slower performance. Which one is better depends on the needs of the photographer. A photojournalist may opt for the faster camera with a lower pixel count where as a portrait or landscape photographer may opt for the higher pixel count.

An image needs to be exposed within the dynamic range of the sensor or film. This is why expert photographers prefer diffuse light (with lower dynamic range) rather than the intense sun of midday. If the sun at midday is too bright the photographer could seek some shade to photograph in. The histogram in a modern digital camera gives an indication to the photographer of where in that dynamic range the light is. The histogram is a graph which shows the number of pixels used for each of the red, green and blue colours and the intensity of the light. The histogram can indicate the risk of the image being too dark, too light or have 'clipping'. Clipping occurs when the light intensity is stronger or weaker than the sensor can handle so information is lost or 'clipped' off due to the camera's finite dynamic range.

In digital sensors, the sensitivity is not perfectly linear from dark to light and varies with colour too. Semiconductor sensors tend to have better performance at the light end of the scale (right-hand side of the histogram). This means that an image taken with a slightly higher exposure value (Ev) with most light energy on the right half of the histogram has a better chance of being corrected in post-processing than an image exposed to the left of the histogram i.e. too dark. This means digital photography has a technique called 'expose to the right' (ETTR). This is opposite to the behaviour of film, where under exposure can often be compensated when printing images from negatives. Careful use of the ETTR technique can help reduce the amount of noise for a given ISO setting because the sensor is given more light which achieves a better signal to noise ratio.

An 'exposure compensation' control is often available in modern cameras. This allows the photographer to force all images to be under or over exposed by the amount set by the 'exposure compensation' control. For example, a digital camera could be set to over-expose by one 'stop' by setting the 'exposure compensation' control to +1 EV. A suggested amount of ETTR compensation is 2/3 stop (+0.7EV) otherwise there is a risk of clipping the highlights i.e. set the 'exposure compensation' control to +0.7 EV. When the 'exposure compensation' control is used it tells the camera to alter the shutter time (Tv) or aperture value (A) by the chosen amount to force the exposure value (EV) to be off-set by that amount. The 'exposure compensation' control is automatically disabled in manual mode. Alternatively, a photographer may choose to set the exposure compensation dial to -0.7EV to slightly under-expose all images. This allows slightly faster shutter speeds or slightly smaller aperture values to be used but risks adding more noise to the image.

All cameras have performance limits which the photographer can often work-around, or work within. Due to the non-linear performance of digital sensors and film, and limited dynamic range, a technique called High dynamic range (HDR) can more fully exploit the limits of the sensor or film. HDR images can be created by merging a series of images of the same scene which have different exposures (EV). Merging the images is usually done in post-processing on a computer but some cameras offer it as an in-camera feature. The result is an image which has a fuller tonal range from dark to light. A similar technique using combination printing from two or more negatives was used in the 1800's by Gustave Le Gray so it is not new! When photographing a static scene such as a landscape, especially when the sky is very bright compared to the land, which may also have shadows, taking three or five shots with slightly different exposure values (change EV by varying the shutter speed) and combining them into an HDR image during postprocessing usually gives a good result. This is often achievable using an in-camera feature called 'bracketing' which allows the camera to take three or five images, each at a different EV. If the scene has moving objects HDR processing may result in blurring or ghosting. Bracketing is explained in more detail below.

Dynamic Range Optimisation (DRO) is a feature available in some digital cameras. The concept is that it lightens the dark areas and darkens the light areas to level the contrasts to within the dynamic range of the sensor. It is usually restricted to changing the JPEG images created in the camera and does not apply to RAW images. Such adjustments can be done in post-processing on a computer so the photographer may prefer to record RAW images and do any necessary adjustments on a computer afterwards, as for HDR.

Exposure affects the colour rendition capability of the sensor. For accurate, true to life, colour rendition the sensor must be operating within its dynamic range. Photographs taken in the intense midday sunlight tend to have washed-out colours. Better colours are achieved in diffuse light. Care needs to be taken when 'expose to the right' (ETTR) is used to ensure colours are not clipped. Colour adjustments can be made in digital image post-processing so the photographer may need to do some colour adjustments on a computer when using the ETTR, DRO or HDR techniques.

Digital cameras offer a number of different exposure metering modes. For multi-area exposure metering the sensor is divided into areas and the exposure level of each area is calculated in the camera and an average taken. An alternative exposure metering mode is centre-weighted metering where the light intensity, hence exposure level, is based on a small centre spot of the sensor. This mode enables the photographer to point the centre spot at the lightest or darkest area, lock the exposure setting to that value, re-frame the image and shoot the picture. The centre weighted exposure control is useful when photographing the moon, for example. The exposure level is normally a dynamic adjustment and it is only held at the point the shutter is pressed. Most digital cameras allow the photographer to lock the exposure setting at a chosen point in time. This is called auto-exposure lock (AEL) or similar title. Some cameras have a feature which causes over-exposed parts of an image to flash on the camera's screen or viewfinder to warn the photographer. A small area of over exposure may be acceptable but larger areas should be avoided.

Bracketing is a long-established photographic technique where the camera takes a few shots each with slightly different settings within a bounded range, such as +/- 3 stops. The camera allows the photographer to select the range of values then the camera takes multiple shots each with a slightly different setting. Some cameras can also merge those bracketed shots into a final image. Bracketing could be used to take a set of shots with different apertures or different shutter speeds (hence different exposure values) or different focus settings. The photographer should learn what the camera offers and consider using bracketing where the required setting is uncertain.

When selecting a lens, the diameter of the lens is a relevant parameter. The larger the diameter the larger the aperture setting can be and the more light can be allowed through to the sensor. The larger the lens diameter the higher the cost because it uses more glass. Low-cost cameras tend to save costs by using a small diameter lens which limits the range of aperture settings available and reduces the amount of light entering the camera. Increasing the ISO setting to compensate for a small diameter lens just results in a grainy image. Lenses with an aperture size larger than f2.8, e.g. f2 or f1.8, tend to be expensive (for a given focal length).

The actual aperture diameter and actual focal-length may be scaled up or down in the camera design by the manufacturer to achieve the standard range of aperture values despite the sensor size. These values are linked to the sensor size and focal length of the lens. The letter 'f' is used to represent the aperture value because 'f' is an abbreviation for focal-length. The point of reference for these actual dimensions is currently taken to be 35mm film size. A full-frame digital sensor has the same dimensions as one frame of a 35mm film. If the sensor is smaller than 'full-frame' then the lens can be smaller, cheaper and lighter.

As mentioned above, the actual f-number is the ratio of the focal length of the lens to the aperture diameter.

These numbers are related to each-other by √2 e.g. f2.8 = f4/√2. This is defined by the following mathematics:

If the diameter of the aperture is, say, 10mm then the area is 3.14159 x 5mm x 5mm = 78.54 sq mm
If the desire is to halve the amount of light reaching the sensor then the aperture area has to be halved to 39.27 sq mm. To achieve this the aperture diameter has to be divided by 1.414 i.e. √2.
If the diameter of the aperture is reduced by 10mm/1.414 to become 7.07mm then the area is 3.14159 x 3.536mm x 3.536mm = 39.27 sq mm which is half of 78.54 sq mm as calculated above.
Each time the area of the aperture is halved the diameter is reduced by √2. This mathematical explanation is only relevant if the student photographer wants to understand the numbers used for aperture settings.

The International Organisation for Standardisation (ISO) has published documents which define the sensitivity of sensors and various types of film. For modern digital stills cameras the document is called ISO 12232:2019. Other ISO standards documents define sensitivity for various types of film. To standardise the definition of sensitivity of the sensor or film a range of ISO numbers are used. The basic ISO numbers are ISO 100, 200, 400, 800, 1600, etc. Each time the ISO number doubles, the sensor sensitivity doubles, thus requiring half the light for a given exposure value EV.

13. Know the Limits of your Equipment

All cameras and lenses have limitations. Knowing these limitations and working within them is necessary for achieving consistently good results. The behaviours of the camera can be explored by conducting a few simple tests as follows:-

Check your digital camera for sensor noise and dead pixels. With the lens cap on and at a set ISO value such as ISO 100, take a series of shots at various shutter speeds from 30 seconds down to 1/30th second. The aperture setting is irrelevant. Examine the resultant images carefully. You are likely to see the images created with a long exposure have a lot of noise which looks like the night sky with white, red and blue stars. The noise is mainly thermal noise cause by the sensor getting hot during long exposures. This is most noticeable in cameras with a physically small sensor. The noise reduces image clarity and looks like soft focus on an image. Some cameras have a feature called 'long exposure noise reduction'. If the image is repeated but with this feature turned on the image should be black with no 'stars'. The noise reduction feature takes two images of the same exposure duration then uses one to cancel the other because the noise is random. The images with a short exposure should be pure black. If there are 'stars' on the images taken with a fast shutter, it is likely to be due to dead pixels e.g. a faulty sensor. Most cameras that are a few years old have a few dead pixels. This is not normally a problem as they can be removed during post-processing of the image, especially if you get to know your camera and where the dead pixels are. The best way to reduce the noise introduced by high ISO settings is to take multiple identical images e.g. 10, 20 or 30 should work well, then use the Stack feature in your post-processing software. The noise in the images cancel each other out because the noise on each image will be different. This technique works so long as the object or scene being photographed is not moving or changing.

Compare the clarity of images taken at each aperture setting. Set the camera in a stable position, such as on a tripod. Take a series of identical shots of an object which is 10m to 15m away, one shot at each aperture setting e.g. f16, f11, f8, f5.6, f4 and ensure the object is in focus each time. Use a set ISO value for all images, such as ISO 100, and adjust the shutter speed to ensure each image is correctly exposed. When examining the images you will see more noise, hence less clarity within the field of focus, on the images taken with a smaller aperture. The images taken with a larger aperture may be clearer within the field of focus. The smaller aperture hence longer exposure time results in more noise, hence less clarity. The images should also reveal/confirm the depth of field for each aperture for the lens. Lenses perform differently too. There are variations due to changes of zoom (for zoom lenses), aperture settings, non-linearity across the image, image stabilisation system, etc.

In-camera image stabilisation (ICS) or in-body image stabilisation (IBIS) can have unexpected impacts on the image clarity too. For example, when on maximum zoom and the camera is stable on a tripod, the ICS can cause the image to drift sideways which can result in a blurred image if the shutter speed is not fast.

If the available light does not allow such a fast shutter speed then that is the time to turn on stabilisation (ICS, IBIS, or optical stabilisation system (OSS) in the lens). If you are using a mirrorless camera you should see a noticeable improvement in image stability as seen through the viewfinder or LCD screen when you turn on IBIS. IBIS usually gives about 5 stops of improvement i.e. allows you to use a shutter speed of 1/15th second with a focal length of 500mm.

In summary: Don't use stabilisation when the camera is stable, such as on a tripod, because the 'hunting' of the stabiliser causes image drift across the screen.

The student photographer should become familiar with the amount of noise introduced for each ISO setting and each shutter speed for their camera. Take a series of identical shots, with one shot at each ISO setting e.g. ISO 100, 200, 400, 800, 1600, 3200, 6400 etc, at a set aperture setting and change the shutter speed to ensure each image is correctly exposed. The noise increases at each ISO increment. Examine the images to understand how much noise is acceptable. By changing the shutter speed to retain correct exposure as the ISO setting is altered, the noise improvement as the ISO number is reduced is partly counteracted by the higher noise caused by the longer shutter time.

For fine art photography it is normally a goal to minimise noise on the image. This is achieved by good lighting of the subject, low ISO setting and short shutter time. The short shutter time has the added advantage of reducing the chance of camera shake causing blurring. The way to minimise noise on the image is to maximise the signal to noise ratio. This is what 'Expose to the Right' (ETTR) does. ETTR is all about increasing the exposure value, normally by slowing the shutter (which may result in more blurring from camera shake) or opening the aperture (which affects the depth of field). When using ETTR care is required to avoid over-exposing the image so that clipping occurs – this is where the histogram comes in very useful. It may be possible to use ETTR to compensate for an increase in ISO setting by one stop. The exposure can then be corrected in post processing on a computer.

Cameras with a very high pixel-count sensor, such as 45MP or 60MP, tend to have smaller photo-sites (smaller photo diodes) than a sensor of the same size with fewer pixels, such as 20MP or 25MP sensor. The smaller photo-sites tend to have slightly worse noise performance which partly counteracts the benefits of the higher pixel count – but this is not always the case! Whether you require a full-frame camera with a high pixel-count of 60MP or a full-frame camera with a more usual pixel count of 25MP with faster shutter speeds and better low-light performance will depend on the type of photography you do. If you do a wide variety of photography you would probably want two cameras, one of each type. Choose the high pixel-count for detailed images such as portraiture and the faster camera for wildlife and sports photography.

A black and white image is not just a desaturated colour image. Black and white film gives images where blacks are true black and white is true white with a range of grey tones between. The overall ratio of black to white is typically 18%, which is what cameras use to determine the correct exposure. To convert a colour image to black and white it is usually necessary to adjust the red, green and blue colours to balance the grey tones, then to adjust contrast and brightness to give the desired effect. The black point should be adjusted, called black point compensation, to ensure there is a black reference point in the image to give context to all the other shades of grey.

14. Post-processing

Modern digital cameras often allow the image to be captured in one or more file formats. Top of the range cameras allow images to be stored using a manufacturer-specific RAW file format. These RAW files contain a lot of information about the image and allow a greater range of post-processing adjustments than most other file formats.

Modern digital cameras also allow the image to be stored in a compressed format called JPEG or JPG, either instead of or as well as raw format. JPEG files are ready to be viewed so very convenient. Raw files need to be 'developed' on a computer and converted to another format such as TIFF or JPEG for viewing. Conceptually, the RAW file from a digital camera is equivalent to the negative from a film camera.

The images from a digital camera can be transferred to a computer for post-processing. A number of software products are available for processing digital images on a computer. A few of the more popular software packages are: 'Photoshop', 'Affinity Photo' and 'On 1'. These software packages vary in price. GIMP (the GNU Image Manipulation Program) is widely recognised as the best free image processing software. These software products can process the raw file formats from the main camera manufacturers as well as JPEG files. They can then save the images in other file formats such as TIFF etc. JPEG files are compressed so are smaller hence faster to transmit so more convenient. TIFF files are not compressed so are larger files and they do not lose image quality. The student photographer is encouraged to understand the various file formats available and choose the most suitable. For example, the camera could be set to store images in raw format, these can be transferred to a computer to be 'developed' and converted to TIFF (or other loss-less format) for storage. The TIFF images can then be converted to JPEG format for transfer or digital projection.

15. Pictorial Effect

Having described light and how a photographer can control it to create an image, this 'introduction' document now goes on to explain the different types of image and their uses. So, this is less about the technology and a bit more about art.

A camera can faithfully reproduce an image of an object or a view. In its simplest form the camera creates a 'record' of the object or view taken. This is appropriate for historic, technical or scientific purposes which require a 'matter of fact' image, known as a '**record shot**' or a '**utility**' shot. Such images are usually lacking in artistic merit but may be technically correct and serve a purpose. That is not the sum total of photography!

From the earliest days of photography, in the Victorian era, photographers such as O G Rejlander and H P Robinson studied the great masters of art painting (Turner, Constable, Moore, Rembrandt, etc) for inspiration for creating pictorial effect in photography. H P Robinson was a successful art painter in his early years then he changed to photography when it became available. He made a successful career from photography until he died in 1901, mainly by doing studio portraits and landscapes. A group of Victorian era photographers, which included H P Robinson, formed an organisation called the Linked Ring whose aim was to promote photography as an art form. Camera clubs also encourage members to create images with good pictorial effect as well as high technical quality images.

Using a camera to create an image with good '**pictorial effect**' e.g. art, which gives pleasure to the viewer is the objective of most (but not all) photographic competitions. Ever since photography was invented there have been critics and sceptics who could not accept photography as a legitimate art form – after all, how hard can it be to press a button! Thankfully attitudes have changed.

Art is intended to give pleasure to the observer. It may or may not be a true likeness of the original object or view. Truth to reality in art is important. However, the photographer should do as the artist does – interpret the situation to represent the subject of the image to its best effect and include in the image some emotion or tell a story. The 'interpretation' of what is seen is what differentiates a utility image from art.

When comparing pictures which humans enjoy with those they do not enjoy as much, it can be observed that the more enjoyable pictures have something in common which is missing from the pictures they do not enjoy as much. These differences are called the 'rules of composition'. So if you wish to create pictures, paintings or photographs which are enjoyed by the majority of viewers you would be well advised to use these 'rules of composition'. That is not to say a picture which does not comply with the rules of composition is unenjoyable, it is just less likely to be enjoyed by the majority of viewers e.g. it is possible to break all the rules of composition and still create an interesting picture. In other words, the student artist should begin by learning the rules of composition and only deviate from them after gaining experience and a personal style i.e. do not use the rules as a straight-jacket, just a guide to good practice. Use of the rules should be subtle, not overt. If used in a subtle manner the fellow artist will see what has been done but the casual observer will enjoy the picture without realising why.

Students of photography would be well advised to also study art, particularly the work of the great masters such as Turner, Constable, Moore, Rembrandt, etc. as well as the work of great photographers. The rules of good pictorial '**composition**' can be seen in the works of these great masters and successful photographers, when you know what to look for. e.g. Rembrandt was the widely recognised master of lighting effect in his paintings. The student photographer could research something called 'Rembrandt lighting' as an example of a technique used by painters which can also be used by photographers.

The aspiring photographer should aim to apply those same rules of '**composition**', used by the great masters of art, to make photographic images which are pleasing to the eye. The rules of composition can be broken, but the photographer should do so knowingly. Success in photography is not easy to define or measure or achieve but it can be measured in terms of consensus of opinion by multiple viewers or a panel of judges who are experienced photographers or artists.

In the early 1900's new types of art were created which broke all the traditional rules of good composition and pictorial effect e.g. Surrealism, Cubism etc. The composition used by the 'pictorialists' of the 1800's went out of fashion for a while, but are still valid.

This 'introduction' document does not explain the rules of pictorial composition in any depth because there are already many books and internet sites which go into great detail about the various aspects of pictorial composition, covering:-

- Balance (ensure the picture is restful and in balance i.e. not looking top-heavy or leaning)
- Unity of purpose (keep the picture simple with one main purpose or object)
- Pyramidal forms (use diagonal lines, triangles and pyramids not vertical or horizontal lines)

- Variety (ensure the main object is complemented and balanced by other objects)
- Repetition (have subordinate objects in the image which reflect or mimic that main object)
- Backgrounds (the background can either emphasise or distract from the main object)
- Chiaroscuro (put the lightest light and darkest dark adjacent then use mid-tones elsewhere)
- Breadth of effect (avoid having to many small spots of light or dark, use broader areas)
- Rule of thirds (helps identify the best places to emphasise the main objects in a picture)
- Rule of odds (an odd number of items in a picture adds interest)
- Rules of space (there are different types of space used in pictures)
- Gestalt perception (utilising human psychology as a guide to good composition)
- Colour harmony, colour contrast and the colour wheel (colour compliments chiaroscuro)

A brief introduction to composition for pictorial effect and using some of these aspects of composition is given below.

Note: A good explanation of composition in visual art is available on Wikipedia for the student photographer wishing to explore the subject further.

16. Photographic Procedures (Workflow)

Each photographer should devise their own preferred techniques and procedures for creating pleasing photographic images. This is sometimes called a 'workflow'. This 'introduction' document gives the following suggestion for the student photographer to consider and try:

A simple three-step process for creating images may comprise of the following workflow steps:-

1. **The Idea** = the concept for the image, identifying the time and place and object
2. **The Capture** = operating the camera and lighting to obtain the intended image
3. **The Realisation** = post-processing and mounting of the image to realise the original idea

The idea for an image may be based on what someone else has done before, with or without modification. Good designs are often based on research of what has been done before and enhancing it. Alternatively, it may be something new or significant in some way. Pictures should tell a story and/or convey emotion. The photographer should do extensive research into the place and subject before planning the image. Good photographers spend as much time on researching and planning as they do in the field on capturing the images. It is not impossible but unlikely an outstanding photograph will be captured as a snap-shot. Great photographs normally required a lot of work.

The Capture of the image requires competent control of the camera and other variables external to the camera such as lighting, background and composition. A photographer should consider the lighting first, then consider the background then consider the composition **in that order.** Patience whilst waiting for the right moment (the decisive moment) to capture the image is a significant part of the Capture phase. These elements are then realised into an image by careful control of aperture, shutter, exposure, framing and focus settings of the camera.

The Realisation of the image comes with developing, post-processing and printing or projecting the image to achieve the original idea or intent. A small amount of post-processing of digital images is usually needed to adjust the colours, contrast, black-point, etc to make them representative of the original seen image. Extensive post-processing risks converting the photograph into a 'graphic design' so should be avoided

When capturing an image the **lighting** (natural and/or artificial, direction, etc), the **background** (depth of field, etc), the **composition** (pyramid forms, lines, balance, unity, rule of odds, colours etc), the **exposure** (high-key, low key, chiaroscuro, etc), then **focus** and **framing** of the image are the variables the photographer needs to learn and practice until they become second nature and instinctive, like driving a car. These should be considered in this sequence to form a simple memorable procedure.

The above sequence is fully compatible with the three main elements that make a great image. These are:-

1. **Lighting**
2. **Composition**
3. **Moment (or Content)**

Lighting is explained in some detail above. Without light you can't get a photograph! The more interesting the light the better the image.

Composition includes consideration of the foreground, mid-ground, background, focus, framing, etc.

Moment (or Content) is the 'something special' that changes a good image into a great image. That moment can be an emotion, an event, a story, etc.

Using planned and rehearsed procedures can greatly simplify, hence speed-up, the photographer's actions to achieve the desired result. The features and controls built into modern cameras have been designed and have evolved over many years to give the photographer the ability to control multiple variables in a convenient way. Like cars are designed to have equivalent controls in similar positions for the driver, cameras have similar controls despite who made it. This allows an experienced photographer to pick up any camera and use its main features immediately.

17. Composition for Pictorial Effect

The concepts of a 'record shot' and 'pictorial effect' were introduced above. The term 'record shot' is not derogatory, it is a 'factual' shot as opposed to an 'artistic' shot. An image can be both factual and artistic hence a record shot with good pictorial effect. For example, an ornithologist may wish to have a record shot of a bird in its natural environment, such as a kingfisher sitting on a stick. An image of a kingfisher sitting on a stick will have better pictorial effect if it has good composition compared to the same bird and stick having poor composition. The difference is all to do with lighting, background and the relative positions of the bird & stick to background & foreground objects as per the rules of composition. The stick it is sitting on needs to be good looking too. Human psychology is what makes a picture 'pleasing' versus 'incongruent'; therefore the rules of composition have evolved over centuries and are just as valid today as they were when photography was invented in the early 1800s.

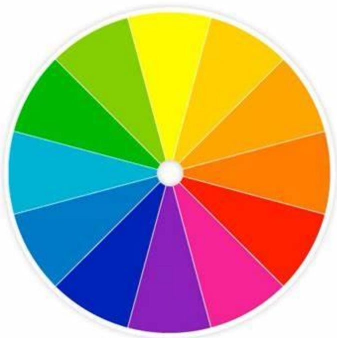
The word chiaroscuro (based on the Italian words for light and dark – the 'c's are pronounced like 'k's) has been used for centuries to describe the range of light and dark areas of a picture or painting. Photographers use this word too. The human eye naturally gravitates to the light or dark areas of a picture. This can be used by the artist or photographer to achieve good pictorial effect. By ensuring the main object or subject of the picture is well lit and the less important areas of the picture are in the shade, the photographer can lead the viewer to concentrate on the picture in the intended way. Having one main object of attention in a picture is called 'unity'. This avoids the viewer being distracted by other objects in picture competing for the attention of the viewer. If a background object is much brighter or much darker than the main object the eye is distracted away from the main object and towards the bright or dark object. The range of objects in brightness and shade can be used to form structures such pyramidal forms, lines and balance. If the main object is light, the picture should have 'echoes' of that lightness elsewhere. Similarly of the main object is dark, the picture should have 'echoes' of that darkness elsewhere. This gives balance. The fact the other objects or areas of light or dark are subdued means it is possible to have 'unity' whilst also achieving 'balance'. It should be clear to a viewer what the photographer's intent is.

If a picture contains multiple objects they should either be presented as an interacting pair or presented as an odd number to give best pictorial effect. A pair of objects can have one positioned so it is more dominant than the other to achieve one 'main' object which is the subject and a secondary 'balancing' object or the two could be equal and interacting such that it is the interaction that forms the 'unity' hence object of the picture.

To achieve good pictorial effect when photographing a group of people it is best to have an odd number of people and to position them to form pyramidal forms i.e. triangles or opposing balanced diagonal lines.

Composing an image with items in the foreground, mid-ground and distance is a way to draw the viewer into the image and give the impression of three dimensions in a two-dimensional image. The use of foreground, mid-ground and distance is sometimes referred to as the 'layers' of composition; not to be confused with the layers used in post-processing software to overlay images and effects.

Modern-day photographers and artists have something which the Victorian era photographers did not; that is 'colour'. Colour could be regarded as a distraction because it is not essential for creating images with good pictorial effect. Some photographers choose to only create black and white images because it requires a particular set of skills. Photojournalists kept on using black and white film long after colour film was available because newspapers were still printed in black and white. When newspapers and magazines adopted colour, the photojournalists began using colour too. Colour is certainly another variable for the modern-day photographer to consider. It requires skills which are not relevant for black and white images. As mentioned above, light has a frequency and the range of frequencies is called a spectrum. As exists in music, light can have harmony and contrasts. If all the visible colours are presented as a continuum in a circle, known as the 'colour wheel' it is possible to explain the effects colour has on pictorial affect.



Colours adjacent to each other on the colour wheel are in harmony because they are similar. Colours opposite each other on the wheel are contrasts e.g. purple and yellow appear on opposite sides of the colour wheel, as do red and green. Contrasts give good pictorial effect, as do colours in harmony. Rather than using lines to draw the viewer's eyes into the image, colour could be used to achieve the same result. A strong colour such as red can form a 'leading line' to aid composition. Use of the colour wheel in graphic design or decorating your home can give pleasing results. Poor choice of colour combinations in graphic design, such as the colour of letters on a background, can make the writing hard to read. If the photographer is colour blind (most often it is males who have colour blindness) he could specialise in black and white photography to achieve success and not bother with colour photography.

18. Post-processing Techniques

From the very earliest days of photography, post-processing has been used to achieve the desired effects hence achieve the goals and vision of the photographer. Well know Victorian-era photographers such as O G Rejlander and H P Robinson and others created photographic images by 'combination printing' i.e. printing images using multiple negatives. Merging the sky or background from one photographic negative with the subject or foreground from a second negative with a (hopefully) seamless join was a new but quite widely used technique in the 1850's. In some cases multiple negatives, as many as nine, were used to create composite images. This has always been regarded as acceptable practice so long as the photographer is honest about its use and does not intend to deceive. The same applies today when doing post-processing on a computer. Some competitions may prohibit the use of extensive post-processing and the use of composite images, where-as other competitions may allow it. This is no different to the techniques used by painters for hundreds of years; the watercolour or oils artist may place a person or boat or other object into a painting that wasn't there just to help the composition and overall pictorial effect. This is acceptable so long as the end result is true to nature and it enhances the pictorial effect.

Good digital cameras allow images to be stored in a RAW mode. RAW mode is where the data from the sensor is store 'as captured' and without any image manipulation, compression or processing in the camera. This can be regarded as equivalent to the negative from a film camera. It needs to be processed before the image can be viewed properly. Camera manufacturers each have their own proprietary raw file formats. The software used for post-processing would need to be able to accept and manipulate the raw files from the make and model of camera used by the photographer. The American software company Adobe has published and made freely available a specification for a raw file format called 'digital negative'. The file names end in '.dng'. This is an attempt to create a de-facto standard for RAW image files to enable portability and transfer of digital negative files between computer systems.

RAW files need to be 'developed' on a computer (or in a camera) to convert them into a useable format. The RAW files contain data about the camera and camera settings as well as all of the image data from the sensor. All the colour information, light intensity and exposure data is present in the raw file. The digital sensor may have a few extra pixels of information around the periphery of the image which can be recovered in post-processing of the raw file. The full dynamic range of light is in the raw file too. RAW files give the photographer a much wider range of adjustment of all image parameters compared to other file formats which have already been developed.

A 'panorama' image is one which is very wide compared to the height. This is often used for landscapes, but can be used for any image type. A panorama image is created by stitching together multiple images to form a wide composite image. The joining of images is done during post-processing on a computer. Good postprocessing software provides a feature for combining multiple images into a panorama. The software looks for overlap between images then aligns the images to form a seamless join. To take a series of photographs for post-processing into a panorama the photographer needs to consider the need for image overlap and should ensure the points of overlap have multiple edges for the software to use for alignment – the software can't align featureless or low-contrast images. As the photographer turns to take each image, consideration must be given to maintain vertical alignment too because the software will create a panorama image with variations in vertical alignment and the panorama can only be cropped from the image between the lowest top edge and highest bottom edge. To maximise the height available, the photographer can position the camera in portrait position (sideways) and take more images horizontally. A tripod with rotating head is very helpful in creating panoramic images. An example of a panorama:

Multi-megapixel images can be created by combining images vertically as well as horizontally. This can be achieved by creating multiple panorama images then combining those vertically (or turning them through 90 degrees and creating a panorama from multiple end-on panoramas). The ability to stitch together multiple images, both vertically and horizontally, allows exceptionally high-resolution images to be created using a digital camera with a modest pixel count.

Note: Some cameras have the ability to do 'pixel shifting'. The sensor in a digital camera uses a mosaic of sensors to collect the RGB colours for each photosite (pixel). By shifting the sensor slightly in two dimensions allows the camera to gather more pixel data thus creating a higher-resolution multi-pixel image automatically.

Post-processing software also allows multiple images to be stacked or overlaid on top of each other. This can allow the pixels which are identical in the majority of images to be used and the pixels that are different in the minority of images to be discarded. The resultant image is to create an image which has all the static objects visible and any moving object is removed. This is very useful when the intent is to photograph a building or scene when there are vehicles or pedestrians moving past. By taking multiple images, such as twelve or fifteen, then stacking them in the post-processing software, the resultant image will be free from any moving object, leaving just the static items – it can make a busy street appear empty.

A stack of multiple images, say ten to twenty (suggest not more than thirty), will also remove noise or grain from the images. Because noise, mainly caused by high ISO settings, is random the stack can take the median or mean value of the pixels thus eliminating random noise. Good image processing software can align the images so multiple images from a hand-held camera can be aligned and the ISO noise removed if sufficient similar images are used in a stack.

Another type of image stacking is known as '[focus stacking]' or 'focus merge'. This is where multiple images are overlaid and the areas of the images in focus are retained and the areas which are blurred, hence out of focus, are automatically rejected by the software. The end result is an image with exceptionally good depth of field. This is only effective if the images are identical in all respects apart from focus. It does not work too well if the images contain objects which are moving. An example of a focus-merged image:

Good post-processing software allows image adjustment layers to be added on top of the original image. This ‘non-destructive’ approach allows post-processing adjustments to be un-done. When the required adjustments have been completed the resultant image can be exported to consolidate the layers. An example of an image which has been created by overlaying multiple images of a tree, each taken at a slightly different viewpoint:

Printed images are normally mounted on mount-board for exhibitions or entry into competitions. The mount frames the image so the colour of the mount-board can be selected to give a good contrast to the image to present the image to best effect. In some cases the image is shown on a computer screen or projected, in which case the background may be dark. If the image is dark and background is dark there may not be a good definition to the edge of the image. If this is likely to be the case a thin border can be added to the image by the post-processing software. This is known as a 'keyline' or 'outline'. The 'outline' should not be too intrusive so should be a neutral shade such as cream or grey rather than red or yellow.

As mentioned above, manipulation of images during post-processing is widely accepted as a way for the photographer to realise the original intent so long as competition rules do not prohibit it and the photographer is open and honest about its use. Extreme amounts of post-processing could remove most, or all, of the original photographic image. This is where the image ceases to be 'photography' and becomes 'graphic design' instead. It is all 'art' so there are no hard and fast rules unless the competition rules state otherwise.

If the photographer uses film it can be converted into a digital image afterwards by scanning. The film is developed in a chemical bath as normal then the negatives are scanned electronically to create a digital copy of the image. A very high-resolution digital scanner designed for the purpose can create very good digital images from film negatives. The negative image can then be converted into a positive image by the post-processing software then adjusted as described above. Note that a scanned negative may not give as much scope for manipulation as an equivalent raw file.

19. Printing

Picture sizes typically follow either of two popular standards. Photographs are historically printed in a series of imperial sizes such as 6" x 8" or 12" x 16" etc. Alternatively, pictures can be printed on popular metric paper sizes such as A4 or A3 etc. Picture mount boards can be purchased with pre-cut apertures for either of these picture size ranges e.g. A3 or 16" x 12" which are similar but slightly different. Some print companies are now offering 12" x 18" prints which have a 2:3 aspect ratio which matches the aspect ratio of 35mm film and 'full frame' digital image sensors.

Any image size can be used for club competitions so long as they can be mounted in 50cm x 40cm mount board. e.g. a 'letter box' aperture can be used for mounting a panoramic image so long as it is less than 50cm wide.

Photographs are normally printed using ink jet printers rather than laser printers because inkjet printers tend to give better quality and higher resolution images. The inks used have a significant effect on the end-result in terms of colour and longevity. Printers designed for printing photographs tend to have more ink colours. Low-cost printer inks are dye-based so tend to fade after six to twelve months. High quality pigment-based inks should be used to print photographs. Dye-based inks soak into the paper which is better for low cost and fast drying bulk printing of office documents. Pigment inks sit on the surface and take longer to dry but give sharper images as required for photography.

Photo paper (e.g. gloss, satin, matt, etc) can be purchased for printing photographs using ink-jet printers. These tend to have a coating to support the pigment inks and to give accurate colour rendition. The type of paper used for printing photographs should be chosen based on the image to be printed. e.g. an image with pale pastel shades may look better of fine art or matt or satin paper whereas nature photos may look better on gloss paper. The photographer should choose the most appropriate paper to use to present the image in the best or intended format.

20. Picture Mounting and Presentation

Mount board

For most photography club competitions a printed picture should be mounted on a card surround called a mount board. Mount board is typically 1.4mm thick card up to 50cm by 40cm. Plain mount board can be bought and the opening or aperture for the picture can be cut to meet the size of the picture. Mountboards with pre-cut apertures for A4, A3, 16”x12” etc images can be bought if preferred or when a mount board cutter is not available. The colour of the mount board is significant. A white or cream colour is most versatile and suited for most styles of picture. For some pictures a black or dark grey mount board is more suited. Use of novelty colours is discouraged but can be used if considered appropriate for the picture.

Cutter tool

There are a range of different styles of mountboard cutting tools. The old saying ‘you get what you pay for’ tends to apply here. Choose a robust metal-framed cutter with adjustable cutting depth and markers for the cutter start/end points. The blade should be at an angle of approx. 45 degrees to form a bevelled edge to the aperture. Some cutting tools may also have a vertical cutter for edging the mountboard. When cutting the mountboard aperture it should be cut from the rear of the board (so sliding the cutter across the board does not mark the front face of the board) by using a ruler or long straight edge to guide the cutter. By putting light pencil lines on the back of the mount board, they can be used to help start and end the cut in the right places thus avoiding under-cut or over-cut. After using the cutter tool a sharp knife such as a ‘Stanley knife’ (or equivalent) may be needed to complete the cut in each corner of the aperture to free the surplus board being cut out of the mount.

Calculating the Mountboard Cuts

Calculating the required aperture size and determining how to centre the aperture requires careful calculation. Example method and mathematics are as follows:-

Step 1:
Measure the external dimensions of the mountboard to check its overall size. For displaying prints at a camera club the maximum dimensions are normally 40cm by 50cm. e.g. Cut the mountboard down to 40cm by 50cm if it is larger, ensuring the corners are 90 degrees.

Step 2:
Measure the size of the image that you want to mount – this is not necessarily the dimensions of the paper the image is printed on, but should be the size of the picture that you want to display, hence the desired aperture dimensions.
Note: If the print is A4 or A3 and borderless then the aperture required should be slightly less than the dimensions of the paper to allow it to be secured behind the aperture.

Step 3:
Decide on the orientation of the image in the mount, the orientation of the mount, and decide whether you want the aperture central in the mount or off-set to form a ‘drop-mount’ (where the lower border is larger than the other borders).

Subtract the width of the image from the width of the mount – that gives the total border width
Subtract the height of the image from the height of the mount – that gives the total border height

Divide the total border width by two to halve it – call this the ‘half border width’ dimension
Divide the total border height by two to halve it – call this the ‘half border height’ dimension

Step 4:
On the back of the mountboard, using a pencil with a fine point and a long ruler or straight edge, draw lines in from the edges to mark the ‘half border’ dimensions for width and height respectively. Visually check that the pencil lines have put the correct aperture size in the required place. Offer-up the image to the pencil lines to check the calculations i.e. measure twice before you cut.

Step 5:
With the mountboard face-down on a cutting mat, with pencil lines showing upwards, position a long ruler or straight edge along the outside of one of the pencil lines (the ruler rests on the outside border area, not on the aperture area). Using the 45 degree cutter tool, with the blade pointing downwards and towards the outer edge of the mountboard, align the start point of the cut with the pencil line that is 90 degrees to the line to be cut. Push the cutter tool in to the board and against the ruler, smoothly pull the cutter along the edge of the ruler whilst holding the ruler firmly. Stop the cut when you reach the pencil line at the far end of the mountboard and at 90 degrees to the line being cut.

Move the ruler to the next line and cut that, then repeat so all four lines are cut.

In theory the aperture board should fall out but in practice you may need to carefully cut the last fibres in each corner with a knife to release the aperture. Discard the board that came out of the aperture, or keep it for mounting a smaller image in the future.

Because the cutter blade is at 45 degrees and the aperture as measured and marked on the back of the mountboard (the uppermost side whilst cutting) it will be slightly smaller than the aperture measured on the front of the mountboard because of the 45 degree bevelled edge to the aperture. If the board is 1.4mm thick and cut at 45 degrees then the aperture measured on the front of the mountboard will be 1.4mm bigger all round (2.8mm in total) than the aperture measure on the back. It is the smaller aperture, as measured on the back that defines the amount of the image being viewed from the front through the aperture.

Step 6:
Align the print on the back of the mountboard and use some masking tape on each corner to temporarily hold the image in place so it is approximately aligned with the aperture. Turn the mountboard over to view the image from the front, through the aperture. Move the image to aligning it perfectly by releasing the tape in the corners, one at a time. When the image is perfectly aligned with the aperture, secure the print to the back of the mountboard using masking tape or other mounting tape along all four edges of the image – that stops the print ‘gaping’.

Step 7:
Check the back-board is the same dimension as the mountboard (50cm x 40cm) and trim if it is oversize. Fit a back-board by gluing it to the back of the mountboard and label the mounted picture with its title to complete the job.

Cutting mat

To protect the table or work surface a cutting mat should be used. The mat could be some spare mount board. A purpose made cutting mat can be bought. Such purpose made mats have metric and/or imperial measurement scales on with a grid. The grid on the mat simplifies measurements and getting the cutting lines straight and perpendicular.

Back-board

To protect the photograph behind the mount aperture, a backing board of similar thickness to the mount board should be used. The back-board should be glued to the front mount board rather than using adhesive tape because tape may damage other pictures if stacked together.

Picture labelling

For most photography club competitions the mounted picture should be labelled with the name of the image using a small paper label in the bottom right corner, positioned diagonally and secured on the back of the mount. The name of the photographer, the name of the photographer's club and the image name should also be on the back of the image.

Annex A - The Timeline of Photography (and other significant dates in context)

Ancient Mankind – Humans have been creating art for tens of thousands of years. Cave and rock paintings have been found in South-east Asia and Europe which are estimated to be about 40,000 years old. Paintings on rock in Australia are believed to be nearer 60,000 years old.

1200's – Alchemists discovered that mixing silver with any of the halogens (bromine, chlorine, iodine, fluorine) formed a set of chemical compounds called Silver Halides that reacted to light and turned them black. They initially called it 'Lunar Caustic' because it looked like the moon. In particular, Saint Albertus Magnus (b.1193 – d. 1280) was a German Catholic friar, bishop and alchemist. He experimented with photosensitive chemicals, including silver nitrate. He is also credited with the discovery of arsenic.

Italian painter and architect Giotto di Bondone (b.1267 – d.1337) used painting to depict religious scenes in Italian buildings.

1300's to 1700's - Art painting was used for religious purposes in Europe and the far-east during the middle-ages. The 14th, 15th, and 16th centuries are known as the Renaissance period where art painting and pictorial composition evolved significantly. People demonstrated their religious commitment by investing in religious art which funded its development. Techniques such as chiaroscuro and colour composition evolved during this time.

Science was also evolving rapidly during this time. The Royal Society, formally known as The Royal Society of London for Improving Natural Knowledge, was founded on 28 November 1660. It was granted a royal charter by King Charles II as "The Royal Society". It is the oldest national scientific institution in the world.

Wealthy people commissioned the best artists of their time to paint their portrait. A number of fine-art painters did remarkable paintings and became known as the 'great masters'. For example, Rembrandt Harmenszoon van Rijn (b.1606 – d.1669) was a Dutch painter who is highly regarded for the way he represented light in his paintings.

The 'industrial revolution' began in the UK in 1760.

Sir Joshua Reynolds (b.1723 – d.1792) was an English painter, specialising in portraits. Reynolds was knighted by King George III in 1769. He advocated the idealisation of the imperfect i.e. art representing truth but at its best. A self-portrait of Sir Joshua Reynolds:

The Royal Academy of Arts was founded in 1768 by Sir Joshua Reynolds. He was its first president. Its purpose is to promote the creation, enjoyment and appreciation of the visual arts through exhibitions, education and debate.

The Royal Institution of Great Britain was founded in 1799 by the leading British scientists of the age. Along with the Royal Society and Royal Academy, these organisations went on to play a significant part in the evolution of the science of photography and photography as an art.

1802 – In June 1802 Sir Humphry Davy published a paper in the Journal of the Royal Institution of Great Britain on the experiments of his friend Thomas Wedgwood (son of potter Josiah Wedgwood). This was the first written account of an attempt to produce photographs using a silver halide compound. Thomas Wedgwood could record silhouettes of objects placed on the coated paper, but he was not able to make them permanent.

1803 - Denmark-Norway became the first country in Europe to ban the African slave trade.

1807 – The UK and USA both abolished the Trans-Atlantic slave trade.

1815 – The Battle of Waterloo took place in Belgium on Sunday 15th June.

1819 – Princess Alexandrina Victoria of Kent was born 24th May, later to become Queen Victoria.

1820's – Scientist Henry Fox Talbot experimented with and published documents on chemical changes to colour, including the effects of the silver halides. A photograph of Henry Fox Talbot:

1825 – Joseph Nicéphore Niépce created the earliest engraved plate of a real-world scene using a silver nitrate photoresist which allowed the plate to be permanently etched. He used a camera obscura, which was a hole in a wall, to expose the sensitised plate to light inside a darkened room:

1830 – Henry Peach Robinson was born on 9th July in Ludlow Shropshire. His father John Robinson was a schoolmaster and his mother Eliza Peach was an amateur artist.

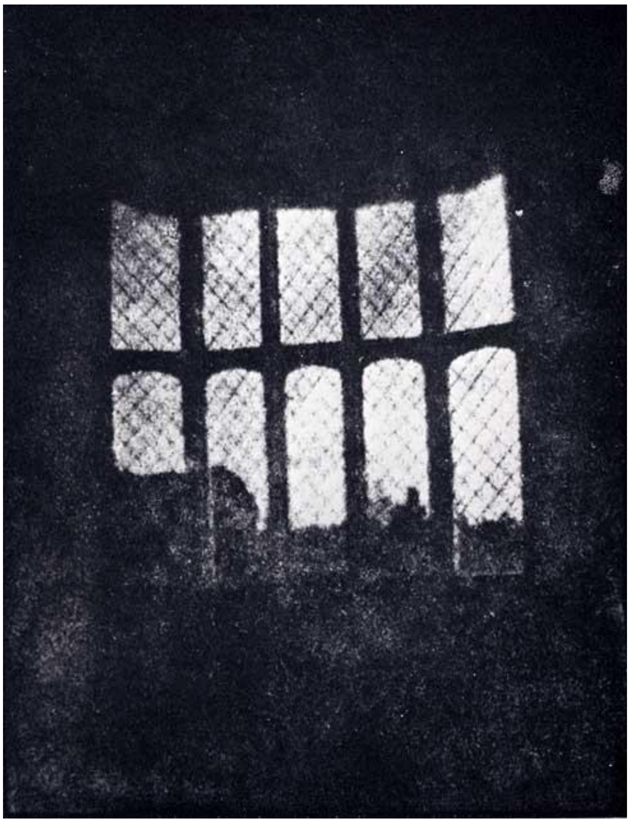
1831 – Henry Fox Talbot became a member of the Royal Society of London for Improving Natural Knowledge (Royal Society) in 1831 for his work on integral calculus.

1833 – Slavery was abolished by the UK via Parliament with Royal Ascent by King William IV.

1837 – Victoria became Queen on 20th June (her Coronation was a year later on 28th June 1838)

1839 – In early January Louis-Jacques-Mandé Daguerre announced that he had created a method for creating images using light, which he called the Daguerreotype, but he did not reveal his method. Daguerre collaborated with Niépce and they sold the rights to the French government.

In response to the announcement by Daguerre, Henry Fox Talbot exhibited several photographs at the Royal Academy of Arts in London on 25th January 1839 which he had created in 1835 e.g. his image titled ‘Latticed window at Lacock Abbey’ was created in August 1835:



Talbot published his calotype process six-months before the French government published the Daguerreotype process. Talbot restricted the use of his process by patent but the Daguerreotype process was 'public domain'. Both methods created one image which could not be replicated.

1840 – The end of the industrial revolution in the UK.

1843 – An informal grouping of photographers called the Edinburgh Calotype Club was established. Henry Fox Talbot's work in the 1840s on photomechanical reproduction led to the creation of the photoglyphic engraving process, the precursor to photogravure. He was also a noted photographer who published his photographs which contributed to the development of photography as an artistic medium.

At the age of 13 Henry Peach Robinson learnt to draw and became an apprentice printer and bookseller in Ludlow.

1845 – Earliest known photograph of Queen Victoria, with her eldest daughter, was taken in either 1844 or 1845:

1847 – The albumen silver print method was published in January 1847 by Louis Désiré Blanquart-Evrard and was the first commercially exploitable method of producing a photographic print on a paper base from a negative. It used the albumen found in egg whites to bind the photographic chemicals to the paper.

1851 – The collodion 'wet plate' process was created by Frederick Scott-Archer to replace the use of albumen. Collodion is a sticky liquid which dries as a clear flexible material originally used in medical dressings. It was used by Scott-Archer to stick silver nitrate to a glass plate, hence creating a 'negative', which can then be printed many times on paper coated with albumen silver halide.

The Great Exhibition, organised by Prince Albert, took place from 1 May to 15 October 1851 in a temporary structure called 'Crystal Palace' in Hyde Park London. The 'Crystal Palace' structure was moved to South London in 1854, but it burnt down in 1936. Many photographs were exhibited at the Great Exhibition which boosted the popularity of photography.

1852 – Henry Peach Robinson exhibited an oil painting titled 'On the Teme Near Ludlow' at the Royal Academy of Art and was recognised as a competent painter. That same year he began taking photographs regularly.

The first photographic society, called the Leeds Photographic Society was established in 1852 and claims to be the oldest photographic society in the world, but it ceased to exist between 1878 and 1881 so its existence was not continuous.

1853 – The Photographic Society of London was formed by Sir Charles Eastlake, the president of the Royal Academy. Queen Victoria and Prince Albert bestowed Royal Patronage on the Photographic Society in 1853 but it was not known as the Royal Photographic Society of Great Britain until 1894. The inaugural meeting of The Photographic Society of London was held on 20th January 1853.

Photographer Roger Fenton became the Society's first secretary, a position he held for three years. With the arrival of the collodion wet-plate process, Photographic Societies were established across Europe (France, Austria, Germany and UK) and India. Sir Charles Eastlake invited Sir William Newton to talk on the subject of "Upon Photography in an Artistic View". The aim was to show that photography could be Fine Art like painting. Prior to this, photography was a technology and a technical process.

1854 – The Société française de photographie was founded in Paris.

1855 – Following a meeting with the photographer Hugh Welch Diamond, Henry Peach Robinson decided to devote himself to that medium and opened a studio in Leamington Spa selling portraits.

1856 – The collodion 'wet plate' process required the glass plate to be sensitised and exposed to light and developed all within a matter of minutes. This was refined by Dr Richard Hill Norris, a doctor of medicine and professor of physiology at Birmingham University. He took out a new patent for a 'dry plate' in which the silver nitrate and collodion emulsion was coated with gelatine or gum-Arabic to preserve its sensitivity for a much longer time. This allowed a glass plate to be sensitised on one day then exposed to light in a camera at a much later date. Other people refined the process further such that the 'dry plate' collodion process became the main form of photography for many years.

H P Robinson and O G Rejlander together founded the Birmingham Photographic Society.

1857 – Since the creation of various Photographic Societies around the world several photographers began to produce composite prints using multiple negatives to create Fine Art. A famous example of this style was by O.G. Rejlander (b.1813 – d.1875), a Swede who was practising photography in England. He joined 30 negatives to produce a 31-by-16-inch print entitled *The Two Ways of Life*:

This photograph was bought by Queen Victoria for Prince Albert.

Henry Peach Robinson became a member of the Photographic Society of London

1858 – Inspired by O.G. Rejlander, Henry Peach Robinson achieved fame with a five-negative print titled ‘Fading Away’ which fashionably depicted a young woman dying of Consumption (Tuberculosis) which was prevalent and untreatable in that era:

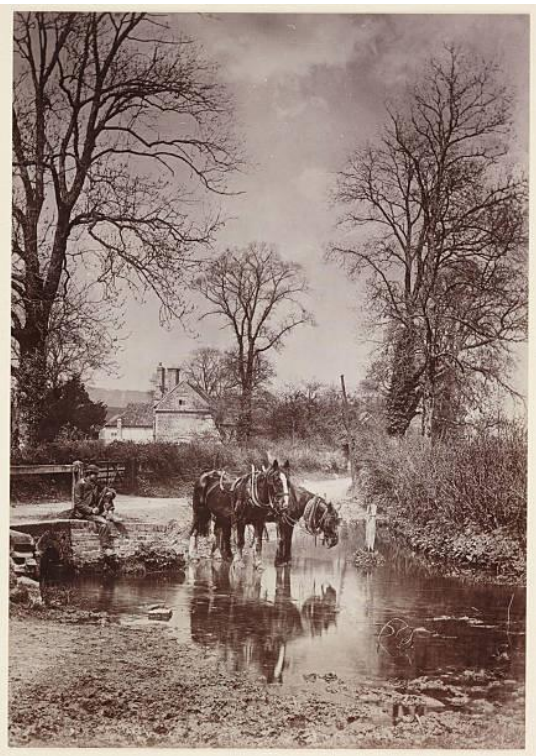
1869 – Henry Peach Robinson, an active member of the Photographic Society of London, published his first book titled ‘Pictorial Effect in Photography’. At the core of his argument was the assumption that rules set up for one art form (painting) could be applied to another (photography). With extensive references to Sir Joshua Reynolds and other famous painters Robinson explained how photographs with ‘good pictorial effect’ can be created by an artist using photography. This approach to photography became known as the ‘Pictorialist’ style of photography.

1877 – Henry Peach Robinson published his photograph titled ‘When the Day’s Work is Done’. It was made using six negatives:

1880's – Photographer Peter Henry Emerson (b.1856 – d.1936) proposed that photographs should reflect nature. He believed that the unique qualities of tone, texture, and light inherent in photography made it a unique art form and making any embellishments for the sake of "art" was unnecessary. This was a direct attack on the popular tradition of combining many negatives to produce one image that had been pioneered by O. G. Rejlander and Henry Peach Robinson in the 1850s. Some of Robinson's photographs were compiled from twenty or more separate negatives combined to produce one image. This allowed the production of images that could not have been produced indoors in low light. Combination printing also made possible the creation of highly dramatic images using high dynamic range, as created by Jean-Baptiste Gustav Le Grey (b.1820 – d.1884). In 1888 Emerson published a photograph titled 'Pond in Winter' which is an example of his naturalistic style of photography e.g. plain photography using one negative:

The leading UK photographers of the time (Rejlander, Robinson, Emerson, etc), although using different styles, where all advocating that photography is an art form and collectively supported the Pictorialist approach to photography as an art-form, rather than it being just a technical process to record images. H P Robinson wrote about pictorial composition and cited the photographs of O.G.Rejlander, Col. J Gale, etc as examples of good photographic composition. He referred to the work of famous painters like Sir Joshua Reynolds, JMW Turner, Titian, Rembrandt, Sir David Wilkie, etc as sources of learning about pictorial composition for photographers. The 'rules of composition' evident in the painting titled 'Blind Fiddler' by Sir David Wilkie and the composition of other paintings were explained in some depth by H P Robinson in his books. The 'Blind Fiddler' contains unity, balance, harmony, repose, pyramidal forms, counterbalanced lines, replication. Every element in this picture has its place and purpose:

1891 – Colonel Joseph Gale created photographs in the naturalistic style, as advocated by Emerson. His image titled Sleepy Hollow is a good example of his work:



1892 – The Brotherhood of the Linked Ring was formed by Henry Peach Robinson and other photographers who were dissatisfied with the way the Photographic Society of London advocated photography as a technical process. The Linked Ring exhibited photographs like paintings were exhibited – framed and hung at eye-level, contrary to the way the Photographic Society of London exhibited photos from ceiling to floor on a wall:

William Kennedy-Laurie Dickson (b.1860 – d.1935) was a Scottish inventor who devised an early motion picture camera under the employment of Thomas Edison in USA, which initially used a 19mm film then in 1892 it used a 35mm celluloid film created in collaboration with the Eastman company. German scientist Oskar Barnack similarly created a 35mm film for the Leica camera in the 1920s which helped make the 35mm format a popular standard.

1893 – From 1893 to 1909 the Linked Ring held annual exhibitions of photographs in 'salons' which is how paintings were exhibited at the time. In order to spread their views on photography, the Linked Ring admitted to their association some respected international photographers such as Edward Steichen, Alfred Stieglitz, Gertrude Käsebier, and Clarence H. White. Many of these artists went on to form the Photo-Secession in the United States in the early 1900's.

1901 – On 22nd January Queen Victoria died. On 21st February Henry Peach Robinson died.

1902 – The Photo-Secession was a group of photographers who formed in New York on 17th February 1902 after Alfred Stieglitz was asked by the National Arts Club of America to put together an exhibition of the best in contemporary American photography. The group promoted photography as a fine art in general, and as photographic pictorialism in particular, as advocated by Henry Peach Robinson and the Linked Ring.

Photography became affordable and popular during the first half of the 1900's with the Kodak Eastman company leading the way with affordable cameras and film.

In the 1950's digital photography was invented and due to the invention of charge-coupled semiconductor devices (CCD) and low-cost large-scale complementary metal-oxide semiconductor (CMOS) sensors in the 1970's it eventually came to dominate the camera market such that by the early 2000's film photography was the preserve of specialists and enthusiasts. In 1957, the first digital image was produced through a computer by Russell Kirsch. It was an image of his son:

The first colour digital image was produced in 1972 by Michael Francis Tompsett using CCD sensor technology and was featured on the cover of Electronics Magazine. The first digital cameras designed for the consumer market were available in the late 1980's and 1990's. They had low pixel-count sensors. The first digital single-lens reflex (DSLR) camera was the Nikon SVC prototype demonstrated in 1986, followed by the commercial Nikon QV-1000C released in 1988. Digital cameras with 6 Megapixel (and above) sensors became available in the early 2000's making them suitable to be used by professional photographers and journalists.

The Future – The future of photography could take any of several paths. The camera manufacturers tend to chase the money because they are commercial businesses and need to generate a profit. The most money is spent by the main users of photographs which are journalists. There is also a significant amount of revenue from the mass-consumer markets which tend to be mainly driven by the needs of social media at the moment.

Traditional newspapers are declining and both social media and online journalism are growing. This implies that video may become more popular than stills images. Camera technology is evolving away from digital single lens reflex cameras (with a mirror that mechanically flaps up and down and a mechanical shutter) to mirrorless cameras which are equally good at shooting video as shooting stills images.

The next significant step is likely to be a mirrorless digital camera that has no moving mechanical parts, not even a mechanical shutter. Such cameras are likely to be expensive and the preserve of the specialist and commercial photographer who needs the best quality images.

The mass market is likely to be served mainly by mobile phones with increasingly better cameras built-in which can record high quality video, as well as stills images. A stills image is the same as one frame from a video.

The manufacturers of digital sensors can put very large numbers of photo-sites (Pixels) on a single CMOS chip but the limiting factor is the noise performance deteriorates the smaller the photosite. The chip manufacturers are saying they reckon 20 megapixels on a full-frame sensor chip is a 'sweet spot' for dynamic range and noise performance. Although, there are work-arounds like CMOS sensor stacking, back illumination, etc. The size of the CMOS chips can be larger too. In the early days of CMOS manufacturing there was a practical limit to the number of transistors and diodes hence photosites that can be economically fitted onto a chip. It was limited by the defect rates caused by silicon impurities. Now with better silicon crystal purity and better imaging techniques to etch the photosite circuitry onto a silicon wafer, the yield of larger CMOS chips is improving. This means it will become more economic to produce larger camera sensors, bigger than 'full-frame', so medium format and perhaps even full format digital sensors could be mass-produced. This is unlikely to become common-place because a large digital sensor needs much larger lenses hence more glass which means they will be very expensive and very heavy.

The need for high resolution images, particularly high-resolution video, is likely to be limited by the fact human vision has a limited resolution anyway. It can be argued that resolutions greater than 8K HD video are not needed for normal human use. So, in the foreseeable future the trend is towards 8K video. There may be some further evolution in 3D imagery and a much greater use of virtual reality systems which give the users a much more immersive audio-visual experience. Telecoms companies and their digital networks are now evolving in this direction. The arrival of quantum communications, which is now being trialled and about to become common-place, will bring almost limitless speed and bandwidth to global communications and do it with complete security. So, communications links are not likely to be the limiting factor. Cameras, phones and other imaging devices will connect wirelessly to an internet with massive bandwidth hence give instant access to incredible amounts of computing power and real-time information from anywhere. Exciting times are ahead for new technology!

However, the thing that does not change as rapidly as the technology is the human perception of what constitutes art, because that is based on human psychology. Art styles and trends will evolve but what is considered as good art has not changed much over the last three hundred years and is unlikely to change much in the next three hundred years. How we consume that art will change as rapidly as the technology evolves.

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