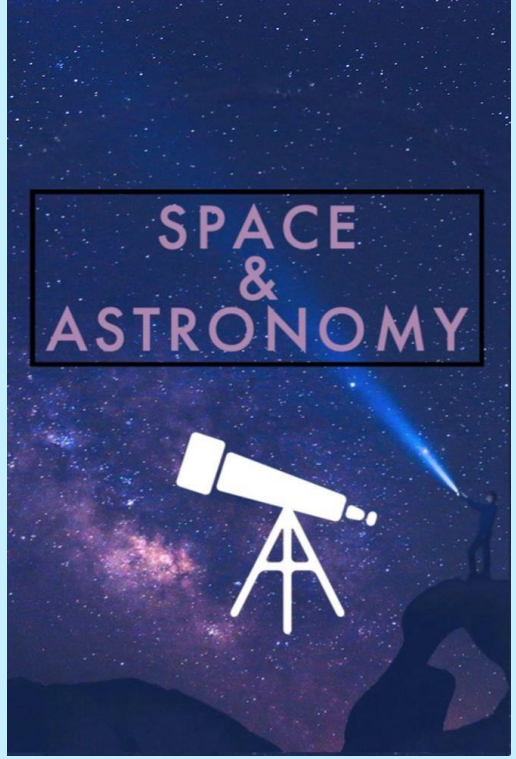

Space, Astronomy and Astrophotography

Dr. Marco Pezzutto

Voices Of the World

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617 × 176

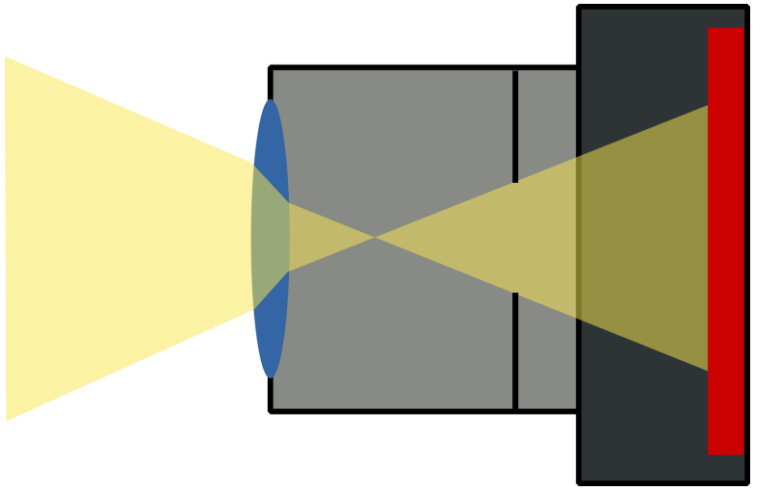
Space and Astronomy

Nevşehir, 19-23 September 2022

Basics of Photography and Cameras

What is Photography?

- A photograph is an image, **two-dimensional static picture**, just like a painting or a drawing.
- From our three-dimensional dynamic world, **light** is collected and **focused** by a **lens** (or just a hole) and projected onto some surface holding a **light-sensitive medium** (a piece of **film** or a **digital** sensor).
- A camera usually allows us to choose **how much light** comes to the sensitive medium, and for **how long.**
- The result is a **static image,** which can be recorded, stored, printed, copied, transmitted.
- Photography in itself is a **technique, a medium, a practice,** a means of creating, images independently of their use, destination and purpose.
- Photography is often used for a variety of purposes and intentions, such as **documentation, evidence, news, artistic expression, persuasion** (advertisement) etc…



What makes a successful photograph?

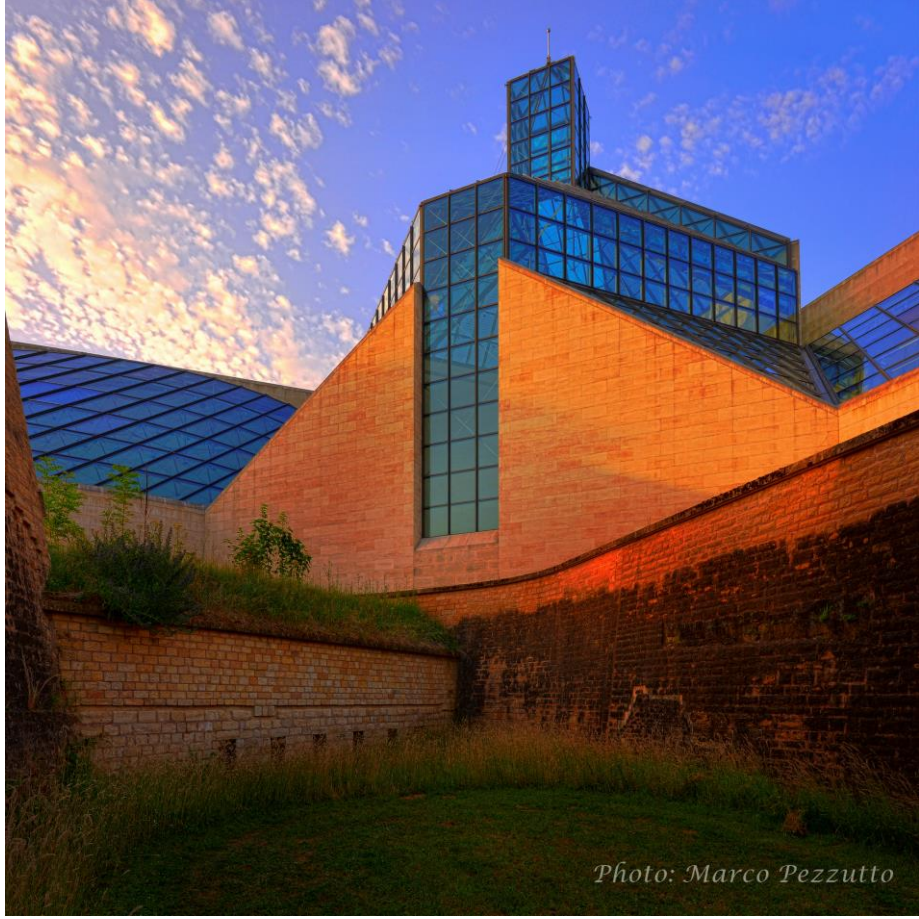
- **Clarity of message**: people looking at your picture should wonder what is it that you wish to say (usually…)
- **Simplicity** of the idea: a simple and direct idea has the highest chance at being conveyed successfully

- Right **time and place**: be there at the *decisive moment*, and be ready to take the picture
- **Planning**: rarely good pictures come out by chance. Most often they are the result of careful *preparation*, *planning, organization, perseverance and* ***patience***.
- **Composition**: the *harmonious arrangement* of the various elements of the picture – Colours, shapes, lines…

> *"From taking pictures OF something, to taking pictures ABOUT something"* – David DuChemin

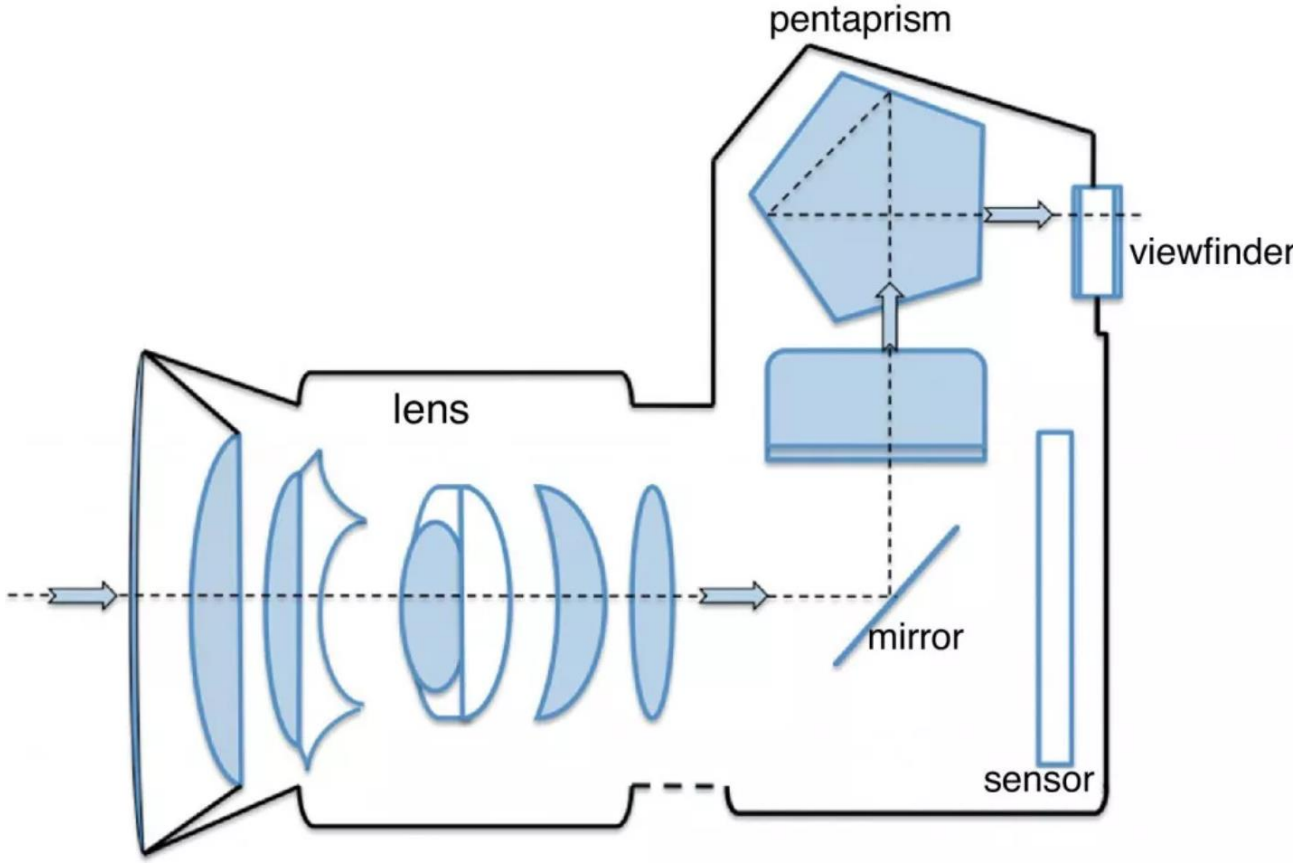
What makes a successful photograph?

- **Capture technique**:
  "I believe you must be a perfect technician if you wish to express yourself as you want. Only then you can forget about technique" – André Kretész, 1977
- **Digital post-processing**: *digital capture* combined with the power of the *computer* (Photoshop, Lightroom etc…) has opened us possibilities of creativity we could only dream of before, and has given to millions of people the access a level of technical image quality which before was strictly accessible only to few skilled professionals.
- **Final display:** even the greatest picture is of little use if nobody can see it! The picture only serves its purpose when it can be displayed and seen, by *you* and *whoever you wish to share it with*, be it on your *social media* account, in your **website**, in a *newspaper*, in a *book*, on the *screen* of your phone or computer, *printed,* framed and hung in *your house*, or in a *photo exhibition*.



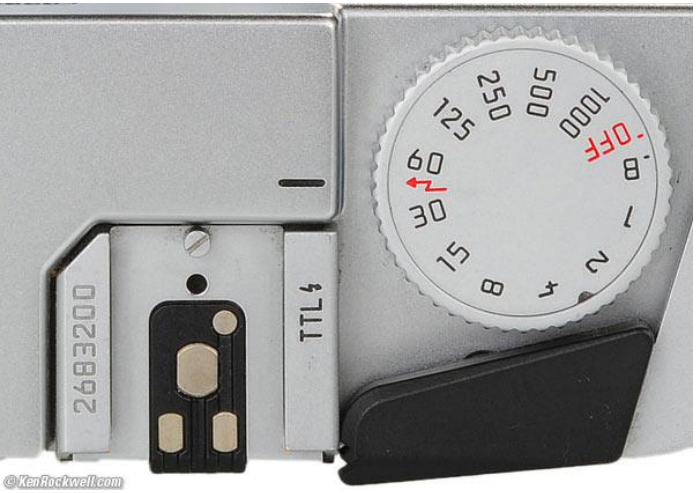
Essential parts of a camera

- **Light-tight box:** creates the dark environment where the light-sensitive material is exposed to light
- **Lens:** *creates the image* – Focuses the light from the external 3D world onto the focal plane where the light-sensitive material is positioned
- **Recording medium:** light-sensitive material, either a piece of *film* or a *digital sensor* + memory card
- **Viewfinder/Pointing device:** allows the photographer to *visualize* in real time how the picture will look like, to *compose* the image, to set the *focus.*
  Types of viewfinder:
  1. **Reflex** (mirror + pentaprism)
  2. **Rangefinder**
  3. **Electronic** (hybrid/mirrorless cameras, smartphones, compact cameras)
  4. **Ground glass** (view cameras)



Essential parts of a camera

- **Lens Focus**
  must be set according to the *subject/camera distance*, to have the sharpest possible image on the focal plane
- **Exposure Controls**
  They *regulate the flow of light*, so that the right amount of light reaches the sensor/film, depending on the external conditions (lighter/darker scene…)
  1. **Lens Aperture**
  2. **Shutter Speed**
  3. **ISO Sensitivity**

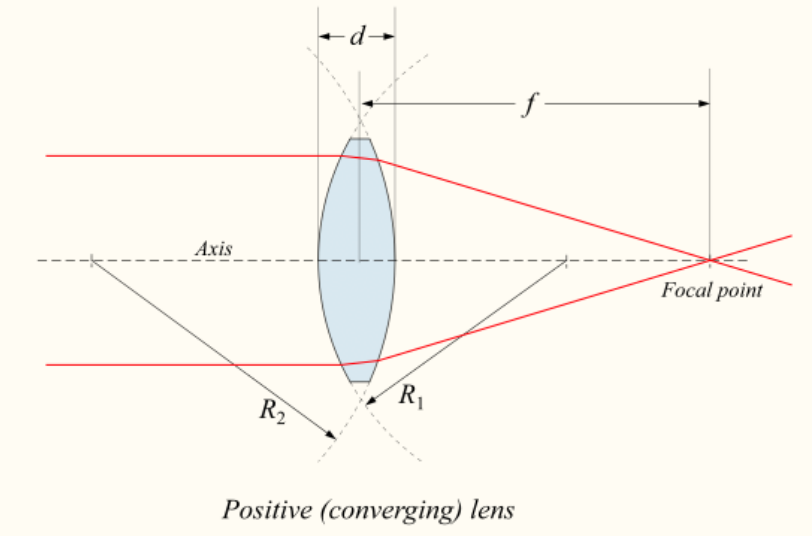


Lens Focus Control

- Any photo lens, no matter how complicated, works essentially like a **single converging lens**.
- Lenses have a key parameter:

Focal Length

The distance behind the lens at which the lens focuses rays of light coming parallel to the optical axis from a very distant objects.

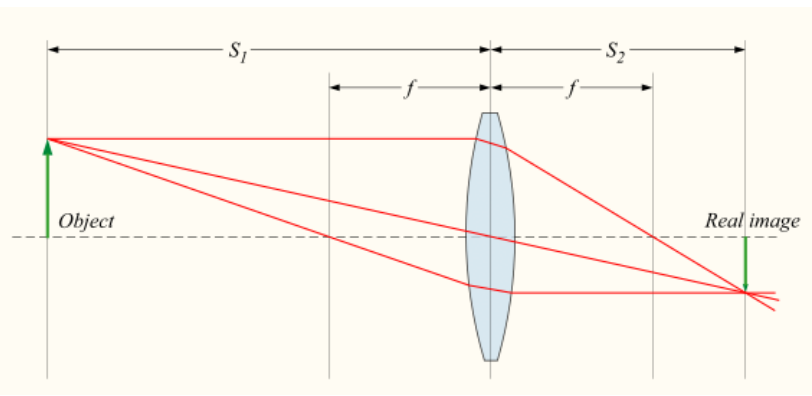


Positive (converging) lens

- Simple lenses work accordingly to the following law:

Lens constructor's rule

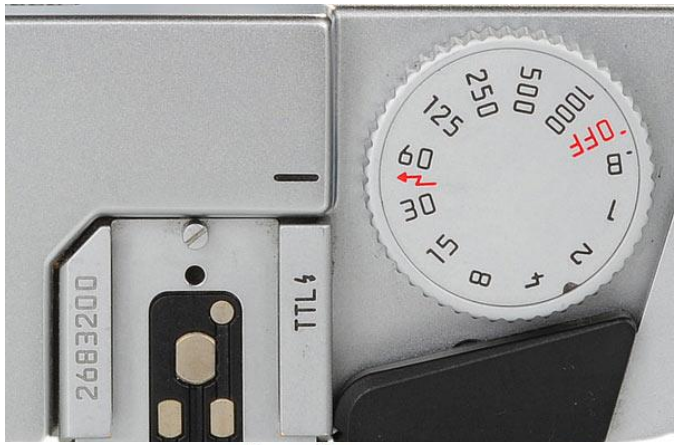
$$\frac{1}{f} = \frac{1}{S_1} + \frac{1}{S_2}$$



- Therefore, the *lens/sensor distance* must be set according to the *subject/camera distance*, to have the sharpest possible image on the focal plane. This corresponds in practice to **focusing the lens.**

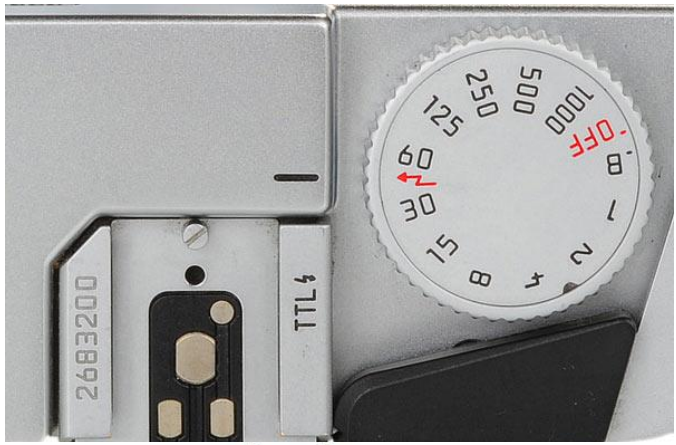
Exposure Control

- All the different scenes we may want to photograph come in a **huge range of light levels**:
  - In plain sunshine it's very bright
  - On a cloudy day it's less bright
  - Inside a home or school or office there's less light
  - Indoors at night, with light bulbs or neon lights, there's even less light
  - Outdoors at night, there's very little light
  - … and the sky at night has a very dim light
- However, our digital sensors (or films) work best when they receive more or less always the **same amount of light**
- Therefore, we need to **regulate the flux of light** coming to the sensor, and the **time duration** for which light can reach the sensor.



Exposure Control

- The **exposure controls** in a camera allow us to make that just the **right amount of light reaches** the sensor:
  - If we gather too much light, the picture will look *too bright*
  - If we don't gather enough light, the picture will look *too dark*
  - If we gather the right amount of light, the picture will look *nice and natural*, and we will use the sensor at the *best* of its possibilities
- In addition, we can **play** with the exposure controls to **make the picture look darker or lighter** than it actually is ☺
- Exposure Control 1: **Lens Aperture** – The *iris* of the lens, how large the hole in the lens is
- Exposure Control 2: **Shutter Speed –** Sets how long the exposure is going to be
- Exposure Control 3: **ISO Sensitivity –** It changes the *sensitivity of the response* of the sensor/film to light
  In film, it is a fixed property of the film itself, depending on the *chemistry* of the film.
  In digital cameras, it is a parameter we can change, a sort of *electronic amplification* of the light.



Exposure Control 1: Lens Aperture

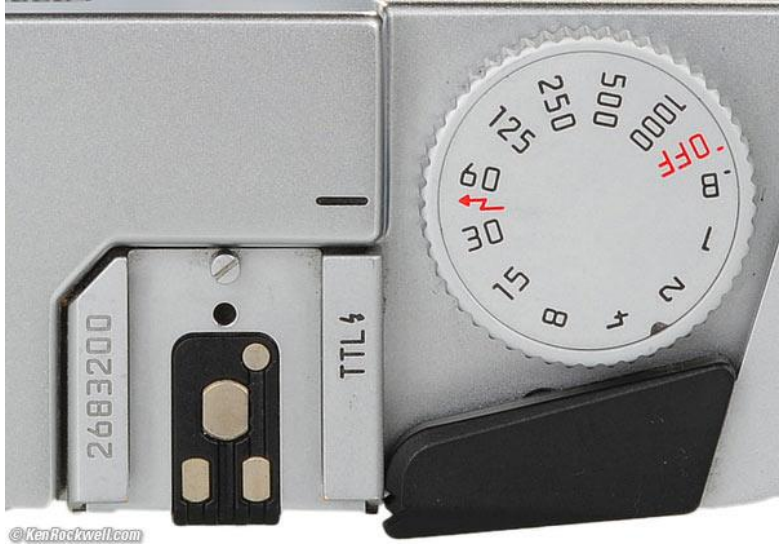
- The lens aperture is the **wideness of the hole** through whish light passes
- It can be changed with a device called **diaphragm,** just like the *iris of our eye* changes the wideness of our *pupil*
- A *wide* aperture lets a lot of light in the camera;
  a *narrow* aperture lets less light in the camera
- The **flux** of light coming into the camera depends on:
  1. **The aperture**
  2. **The amount of light outside**
- If there's a lot of light outside, even a small aperture will collect enough light for a good exposure.
  If there's very little light outside, we need to collect all the light that we can, and use a very wide aperture
- Effect on picture look:
  1. *Wide aperture*: **shallow depth of field –** isolate the subject (in focus) from the background (out of focus)
  2. *Narrow aperture:* **deep depth of field –** a lot is in focus, even at vary different distances from the camera

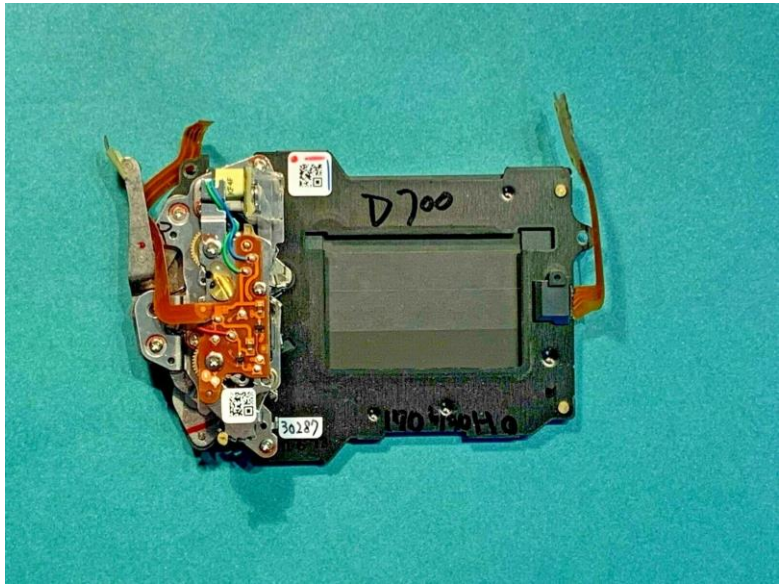
Exposure Control 1: Lens Aperture

- **Typical values of aperture:**
  f/1.0 – f/1.4 – f/2.0 – f/2.8 – f/4.0 – f/5.6 – f/8 – f/11 – f/16 – f/22
  Every successive value represents a decrease of ½ of the flux of light passing through the lens, therefore decreasing the total exposure by ½.
- **Recommendations:**
  1. If shooting hand-held, use an aperture sufficiently wide to collect enough light for a comfortable shutter speed and not having motion blur
  2. After ensuring there's no motion blur, use whichever aperture suits best the picture to be taken
  3. Use a narrow aperture (f/11 to f/22) if having a deep depth of field is desirable, to have everything in focus, near-to-far
  4. Use a wide aperture (f/1.4 to f/4) if having a shallow depth, to isolate the subject (in focus and sharp) from the background (out of focus and smooth)
  5. Use an intermediate aperture (f/5.6 to f/8) if depth of field isn't a concern. This way, the lens will work at the best of its optical performance

Exposure Control 2: Shutter Speed

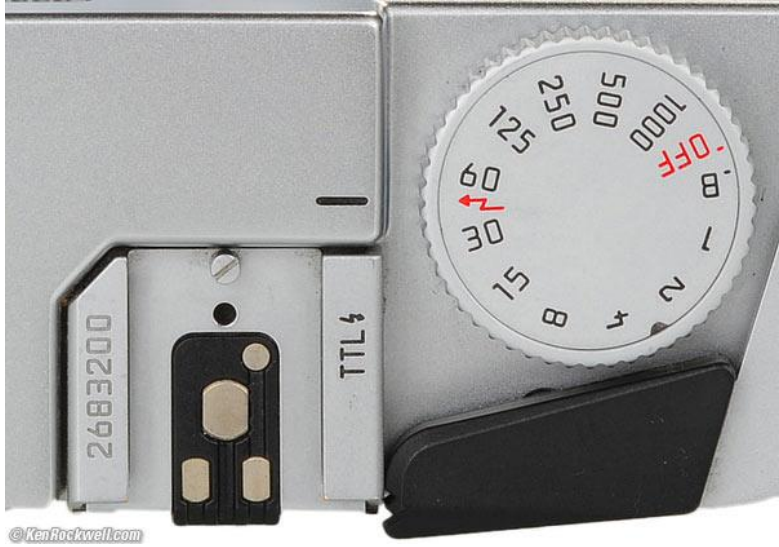
- The *shutter speed* controls precisely the **duration** for which the film/sensor is *exposed to light*
- This is achieved through a *mechanical or electronic device* called **shutter**
- Together with the aperture, the shutter determines the *total amount of light* reaching the sensor
- Effect on exposure:
  - If there's a *lot of light* outside, and/or we are using a *wide* aperture, a lot of light is coming in, therefore a **short shutter speed** (*fast shutter*) will be required
  - If there's *little light* outside, and/or we are using a *narrow* aperture, little light is coming in, so the shutter must stay open for a longer time (*slow shutter*) to ensure enough light reaches the sensor
- There are many different **types of shutter**:
  1. **Focal-plane in-camera mechanical** shutter (all DSLR and rangefinder cameras, most mirrorless)
  2. **Central in-lens mechanical** shutter (many medium format cameras, all view cameras)
  3. **Electronic** shutter (compact cameras digital, smartphones, additional on most mirrorless)

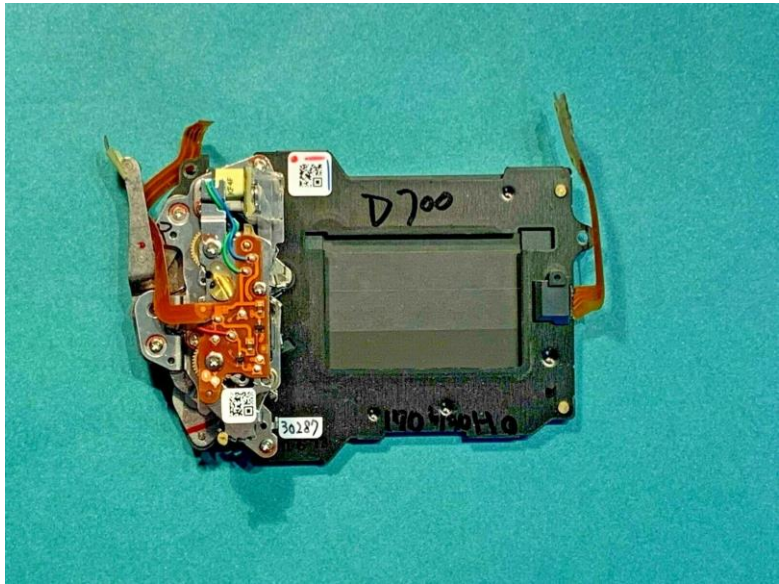




Exposure Control 2: Shutter Speed

- **Typical values** of shutter speed:
  … 8 s. – 4 s. – 2 s. – 1 s. – ½ s. – ¼ s. – 1/8 s. – 1/15 s. – 1/30 s. – 1/60 s. – 1/125 s. – 1/250 s. – 1/500 s. – 1/1000 s
  Every successive value represents a decrease of ½ of the flux of light passing through the lens, therefore decreasing the total exposure by ½.
- Effect on **picture look**:
  1. **Short (fast) Shutter Speed**: *freezes and captures fast motion*, prevents *blur* by *camera shake*
  2. **Long (Slow) Shutter Speed**: anything that moves is not fixed on the picture, instead it leaves a trace, or halo. It may cause blur by camera shake
- **Recommendations:**
  1. If shooting **hand-held**, use a shutter speed fast enough to **prevent blur by camera shake**
  2. If setting the aperture first (for deep or shallow depth of field), use a shutter speed that gives the *correct exposure*
  3. If **freezing motion** is a priority, use the *widest aperture* available on the lens, and therefore the **fastest shutter speed possible** (and also increase ISO, see later…)
  4. If a **long shutter speed** is required than what would be comfortable for hand-holding, use a **tripod and remote release**





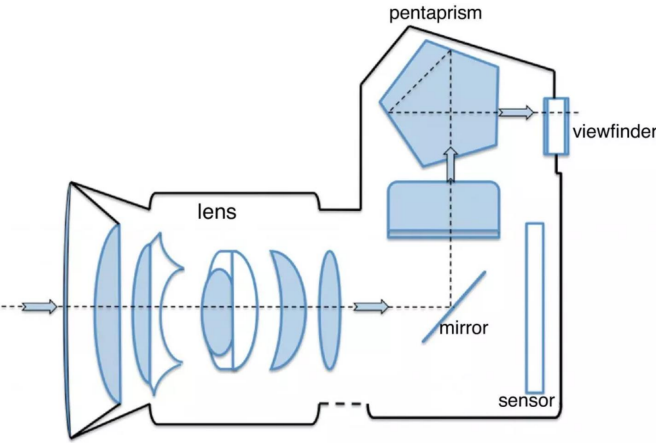
Exposure Control 3: ISO Sensitivity

- ISO sensitivity is a measure of the **responsiveness to light** of the light-sensitive material, be it film or a digital sensor
- In film photography, it is a **fixed property of the film**, given by the particular chemical composition, and cannot be changed.
  One may therefore buy and use *different films* with different ISO sensitivities *for different purposes.*
- In digital photography, each sensor also has an *inherent ISO sensitivity*, called the **base sensitivity**
  (typically between ISO 50 and ISO 200)
- In digital photography, the *light reaching the sensor* generates an **analogue electronic signal.** This signal can be **electronically amplified.** The ISO sensitivity in a digital camera controls the magnitude of this amplification.
- Only *after* the amplification is applied, the signal is **converted from analogue to digital.**
- **Effect on exposure:**
  1. **Low ISO Sensitivity:** *little or no amplification* is applied, therefore the sensor can collect all the light it can, before it *saturates.* This may require a long shutter speed, a wide aperture or both
  2. **High ISO Sensitivity:** *some, or a lot of amplification* is applied, therefore one can *reduce the shutter speed*, or *close the aperture*, or simply shoot when there's *very little light available*

Exposure Control 3: ISO Sensitivity

- **Effect on picture look:**
  1. **Low ISO Sensitivity:** the sensor collects all the light it can with no amplification, therefore working at the *best of its possibilities.* This produces the *maximum technical image quality.*
  2. **High ISO Sensitivity:** the sensor collects a *very dim signal* which is then *amplified*. This can introduce *electronic noise*, which results in image *colour noise* and *decrease of detail and sharpness.*
- **Typical values of ISO sensitivity:**
  50 – 100 – 200 – 400 – 800 – 1600 – 3200 – 6400 …
  Every successive value represents an increase of factor 2x of the electronic signal equivalent to increasing the total exposure by a factor 2x.
- **Recommendations:**
  1. If shooting *hand held*, use always an ISO sensitivity **high enough** to ensure a fast enough shutter speed **to avoid blur by camera motion**.
  2. If shooting *subjects that move*, use an ISO sensitivity **high enough** to have a shutter speed fast enough to **stop motion**.
  3. **A noisy but sharp picture is ALWAYS better than a less noisy but blurred picture**
  4. If *technical image quality* is a priority, use the **lowest ISO sensitivity** *compatible with the light conditions* (but always remember the points above first).
  5. If shooting on a *tripod*, shutter speed is of no concern, therefore use always the **base ISO for best quality.**
  6. ISO sensitivity was much of a concern 5-10 years ago; nowadays cameras got so good that even using high ISO sensitivities like 1600 to 6400 still gives good or excellent results

Types of Still Cameras



- **Single Lens Reflex: 35mm Film (SLR) and Digital (DSLR) Full Frame and APS-C**
  - reflex mirror and pentaprism as viewfinder, the most accurate in the film era
  - focal plane shutter, can be very fast
  - Works great with zoom lenses
  - Often large and heavy
  - Great with normal and telephoto lenses, harder to make wide angle lenses
  - The past and present of photography
- **Digital Mirrorless (Full Frame and APS-C)**
  - The ideal digital camera
  - Electronic finder, the best ones even better then reflex
  - Slowly but steadily replacing DSLR in all segments of photography
  - Cameras are comparatively smaller than equivalent DSLR cameras, although lenses can be small and light but also as large and heavy as DSLR lenses
  - … The present and future of serious and professional digital photography
- **Digital Point & Shoot (Smaller than APS-C)**
  - All-in-one compact cameras accessible to everyone (before smartphones took over…)
  - Light and small and portable
  - Quality NOT comparable with DSLR
  - Disappearing very quickly
- **Smartphones**
  - Always with you
  - Light and small
  - Quick
  - Almost 100% automatic
  - Increasingly more controls and editing possibilities with dedicated apps
  - Immediate share and dissemination
  - … the present and future of MOST of photography!!!

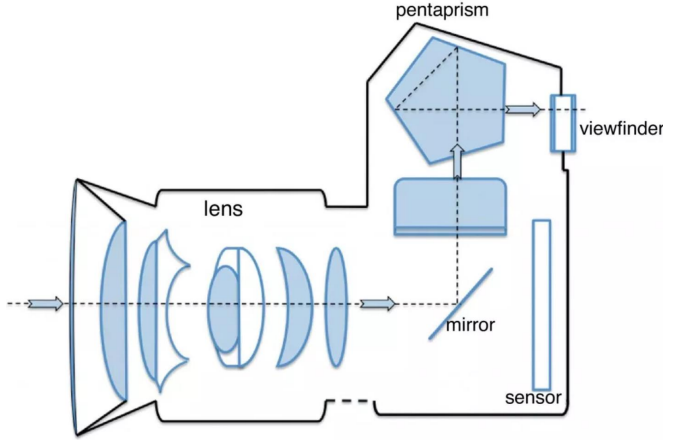
Types of Still Cameras

- **Rangefinder, 35mm film and digital (full frame)**
  - Rangefinder viewfinder, bright and immediate, not as precise as reflex finder
  - More compact than reflex cameras, portable
  - More compact and BETTER lenses, especially wide angles
  - Usually excellent image quality, better than reflex cameras
- **Medium Format Reflex Cameras, 120 film and digital**
  - Incomparably better image quality than 35mm and full frame cameras
  - Much bigger, heavier and more expensive than 35mm and full frame cameras
  - Slower to use, almost always tripod needed
  - All the same advantages of reflex viewfinder
  - In any era, the best quality in a camera that's relatively easy and fast to use (film and digital)

Types of Still Cameras

- **Medium Format 120 Film Rangefinder, and Mirrorless cameras**
  - Film: BEST COMPROMISE EVER between great image quality and portability
  - Digital: all the advantages of mirrorless + all the advantages of medium format
  - Slower to use than 35mm rangefinder and full frame digital cameras
  - … The present and future of digital photography of highest quality
- **View Cameras** (Still mostly film)
  - Highest image quality ever, incomparable to anything else
  - Movements of lens plate and film plate allow for creating pictures that would be impossible otherwise
  - Completely manual operation
  - Very heavy and large to carry
  - Very slow to operate and setup

Types of Viewfinders



- Reflex Viewfinder
- Rangefinder
- Electronic finder: image right from the sensor
    - Point & shoot
    - Smartphones
    - Mirrorless cameras

Image credits

- www.kenrockwell.com
- www.bhphotovideo.com
- www.en.wikipedia.org

Extra material
The Process of Taking a Picture
What happens when you press the shutter

1. Preliminary operations (DSLR only):
   Aperture closes to the taking aperture
   Mirror goes out of the way
2. Shutter opens
3. Recording medium is exposed to light
4. Shutter closes
5. Everything is reset to initial state (DSLR only):
   Aperture opens fully
   Mirror comes back in place (if present)

- **Remark:** in rangefinder and digital mirrorless cameras, steps 1 and 5 not needed