How do Video or TV Cameras work?

All video cameras have three main parts.

1) The **Lens**.
   The lens selects your field of view or what you see and produces an optical image.

2) Imaging or pick up device, which is also called a **CCD** (charged coupled device).
   The CCD converts the optical image into electrical signals inside the camera.

   [Image of a camera lens and a CCD chip]

   [Image of a viewfinder]

   [Image of a beam splitter]

   [Image of a crystal splitting white light into a rainbow]

   http://electronics.howstuffworks.com/camcorder2.htm

3) **Viewfinder**
   The viewfinder shows what the lens sees.

   [Image of a person looking through a viewfinder]

All Video or TV cameras work the same. They **convert optical images into electrical signals**. This means that **light reflects off an object** at which you point the camera.

The lens gathers the light and focuses it through a prism called a **Beam Splitter onto the CCD** (charged coupled device). The beam splitter works via the same way a crystal hung in a window works. When light hits a crystal, it splits the white light into a rainbow of colors. With a video camera, a **beam splitter (or prism) splits the light into three colors: RGB.**

[Image of a beam splitter splitting light]
RGB stands for red, green, blue. Every color that you see on your TV is created from a mixture of Red, Green, Blue (RGB).

So again, the light enters the lens and is focused through a beam splitter, which turns the white light into RGB. Each color goes to its respective CCD.

Remember, a CCD or charged coupled device (Pick device or imaging device) converts the optical image into the video signal or electrical signal. Most video cameras have 3 CCDs, one for each color that makes up the video signal (RGB).

The CCD contains tons of image sensing elements called pixels, which function like tiles making a mosaic. The more pixels, the higher the resolution or the better the picture.

All video cameras work the same no matter how large, how expensive or how cheap. Most people divide them into categories based on their use, or their primary function.

1) Studio
2) ENG/EFP
3) Consumer

**Studio cameras:**

1) very heavy: must use a pedestal
2) will not function independently. Need a camera chain: ccu, vtr, audio board, etc.
3) can be used in studio or on location
4) highest control and quality
5) most expensive, more crew, more time
6)
Studio Cameras are traditionally larger cameras used in a studio setting or for very large events on location. Examples of events warranting studio cameras: professional sporting events, the Olympics, national political party conventions, etc.

Studio cameras are heavy. You would not use one as a shoulder camera to run around gathering news footage. Because of their weight and the added weight of the teleprompter, studio cameras require a pedestal.

A pedestal is a large “tripod” type support that holds the camera. It permits the camera person to raise the camera, to dolly, to truck, to pan, tilt, etc. It is on wheels.

Studio cameras do not function independently. You need the entire camera chain. The camera operator in the studio controls framing, focus and position and movement of the camera. Other operators control everything else.

First, you need a CCU or camera control unit. This is a control in the master control area of the studio. An operator in the back controls the iris and gain (brightness), color balance and contrast of the camera. There is a cable attached to the camera that sends the video signal to the control room so that the camera can be adjusted remotely.

A studio camera does not record the video. The same cable mentioned above sends the video signal to the control room and the signal is recorded into a VTR or onto a server.

VTR is a VCR, only for professional format videotape. No video production is recorded on VHS.

Professionals record to various tape or digital formats. Ex: Beta Sp, DVCAM, miniDV, BETA SX.
A studio camera does not record Audio. The audio is run independently from the camera. Actors and/or talent are miced (have microphones placed on them or pointed at them) and the mics run through either XLR cables or a wireless signal to an audio box with inputs for each mic. This box, called a snake, is connected to a large cable that runs into the master control room to the audio board.

The audio board is connected to the VTR or to the server where the audio is recorded.

What does all this mean? Well, it means that when using a studio camera you need multiple people to do a video shoot. The cameraperson wears a headset and can talk to and work with other crewmembers in the control room. You could not take the studio camera off the pedestal and walk outside of the studio to record an interview or action outside without being attached by a cable to the control room where the CCU, VTR and server are working.

ENG/ EFP CAMERA:

ENG stands for electronic news gathering. EFP stands for electronic field production.

ENG uses a portable camcorder very much like the consumer camcorders that you see in electronics stores and bigbox stores. They are higher quality. When you see a news photographer running
around with a camera on his/her shoulder. That is an ENG/EFP camera.

Unlike a studio camera, an ENG/EFP camera contains all elements required to record video. They do not need a camera chain.

You can control the quality of the image. You control the color balance, white balance, gain, iris, shutter, etc with switches on the camera itself.

The camera also has a VTR or VCR dock where you insert video tape to record.

An ENG/EFP camera has audio inputs so that you can record audio at the camera onto the videotape.

What does electronic news gathering mean?
What does electronic field production mean? What is the difference between the two?

You use the same camera for both ENG and EFP. Here’s the difference:

Most news is not pre-planned. If you are a reporter or a cameraperson, you arrive at the news station for your shift and an assignment editor hands you a story to cover. You pack your gear and head out to the location without any pre-production, or planning. Many times a story will happen at a location you know, or are familiar with. If you are going to city hall, you will have a good idea of what your lighting, space and electrical situation will be, because you’ve probably been their numerous times. You may be heading out to shoot in the rain or in snow or fog. You may be shooting on a bright sunny day, or late at night. You have to know your gear and how to use it to record the best possible video in any situation.
ENG means that you are going out to record an event for which you did not get to preplan. It may be a live event or you may record footage and return to the station to edit a package. ENG may be live or prerecorded.

EFP, or electronic field production means that you had time to pre-produce the event. That means you knew ahead of time, maybe by a day and maybe by months or years when, where and what you were going to videotape. This allows you to plan for the best video. You plan our lighting, audio, angles, and many other factors. Commercials and movies are EFP. A Dallas Cowboys game, a Mavericks game, a Stars game, a music concert at Trees or at American Airlines Center are all EFP.

EFP can be live like a professional sports event or a schedule press conference with the mayor. It can also be recorded for post-production or editing at a news station or production house.

**Consumer Cameras:**
Consumer cameras work the same as an ENG/EFP camera except their CCDs are of lower quality and their lenses and electronics are often of lower quality.

Now let’s talk about the **electronic characteristics common to all video cameras**.

1) **Aspect Ratio** = Ratio of the Width of an image to its Height.
   The traditional tv is a 4x3 rectangle. Widescreen and HDTVs are 16x9.
   You can write that 4x4 or 4:3 and 16x9 or 16:9.

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16x9 tv        4x3 tv
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The cameras we use can switch from a 4x3 framing to a 16x9 framing. The switch occurs in the CCD. When you make this switch from the standard format of that particular camera, you lose pixels in your CCD. Blocking a portion of the CCD makes the switch. To turn a 4x3 into a 16x9 image, the top and bottom are blocked.

Most TV today is shot in 16X9.
2) Resolution

Resolution refers to the detail in the picture and is a major factor determining the quality of the camera. The picture resolution depends on several factors: lens quality, number of pixels on the CCDs and the general electrical signal processing quality of the camera.

Please note that the resolution you see on your tv depends on the entire system not just the camera that shot the footage. It depends on the resolution at which the footage was edited. The quality of the tape dubbing or live signal transmission. The quality of your tv and of your provider’s signal. If you are watching broadcast tv and it is stormy outside, the signal might be fuzzy. If you have satellite tv and there are sunbursts, you can lose picture for a bit.

Lenses: Some lenses are glass and some are plastic. Glass lenses are much better than plastic.

The number of pixels measures CCD quality. A good digital camera may have 400,000 pixels on each CCD. HDTV cameras may have 2 million or more.

MEASURING RESOLUTION.

NTSC or American video signals have 525 lines of video. NTSC = 525 lines. PAL is the European standard and it has 625 lines.

You may see advertisements for cameras with 800 lines of resolution. I just told you that all NTSC cameras have 525 lines of resolution. Are the ads lying? No.

The vertical resolution is always 525 lines for NTSC. The horizontal resolution can be 700 or more lines.

How does this work?

This website describes it well: http://www.edsavhandbook.com/Chapter%20Four%20Page%206%20of%209%20Video%20Rep rodution.html

If you took a piece of paper and started at the top left and drew a line from left to right across the paper, and then drew a line under that line also from left to right and kept drawing until you had 525 lines across the paper, you would have drawn the vertical lines.

“Huh”, you’re thinking? I just drew across the page and that is horizontal, not vertical. Right. But to count the lines one at a time, you would move down the page vertically. I.e. there are 525 vertical lines in NTSC.
So how do you get the 700+ horizontal lines?

Across each of the 525 lines, there are pixels. Each pixel is actually made up of three pixels, one each for RGB.

To create video, an electronic pencil reads across each line zapping those pixels with electricity at various strengths. The more pixels across each of those 535 lines the higher the resolution. You could have 700 groups of pixels across each of the 525 lines, or you could have 900 groups of RGB pixels across each of the 525 lines.

3) **Light Sensitivity**

A camera needs light to produce a video signal so that you can record a recognizable image. How much light is adequate? The answer depends on how much light the camera lens admits and how much the video signal or electronic signal can be boosted before the picture deteriorates.

Cameras are rated by their minimum operating light level at which they can produce images free of distortion and electronic noise. Electronic noise is often called grain or snow, because it shows up in your video as artifacts that look like dark or white spots on the screen.

Gain boosts the electronic signal, tricking the camera into thinking there is enough light to get a good image. The more you turn up the gain, the worse your picture becomes.

Gain is shows on a camera in decibels or dB. 0dB, +2dB, +6dB, +12dB, etc.

Most ENG/EFP cameras have auto gain. When you are shooting news on the fly, you can’t necessarily stop to add light, and you have to get the shot. Your audience understands when news footage is not pretty.

If you are shooting EFP and have time to pre-produce you will not use gain. Add light if it is too dark.

4) **Video Noise**

A noisy picture means there are artifacts, or grain or snow in the image. If the video signal is strong, because the CCD is getting good amounts of light, there will be very little to no noise. If the CCD is not getting adequate light, there will be more noise, grain or snow. I.e. There will be more artifacts on your video screen. An extreme example of
noise is the images taped by security cameras that you sometimes see on the news. They are very low quality.

The relationship between signal and noise is the signal to noise ratio. It is expressed at S/N. You want a high S/N – or a high signal and weak noise.

5) **Image Blur**

CCDs tend to produce blur in pictures of fast-moving objects.

An example, is watching a tennis ball in a professional match on tv and seeing it sometimes blur.

To avoid blur and get a sharp image, use the electronic shutter on the camera. It works like the shutter control on a 35 mm still camera. The slower the shutter speed, the longer the CCD pixels receive light and the more blur you will see on the tennis ball. The higher the shutter speed, the less light that reaches the CCDs and the less blur you see on the all.

As you turn up the shutter speed, less light hits the CCDs. Now remember your S/N ratio. To get a high quality image without noise, grain or snow, you want enough light hitting the CCDs. Fortunately, most events featuring high speed action are in well lit sport arenas. Ex: NASCAR, tennis, baseball, horse racing.

6) **Smear**

Smear is a form of video noise. Bright colors, especially neons and reds can cause smear, which looks like bands moving beyond the outline of an object. It is best to avoid wearing bright red lipstick our outfits to avoid smear.

In this example the skier's legs are smeared.

7) **Moire’**

Moire is a vibrating pattern of rainbow colors dancing across an object on the screen. It is caused by tight patterns like herringbone, tight stripes, plaids, tight weaves, etc.
It happens because as that "electronic pencil" scans 700 + groups of RGB pixels across 525 separate lines of video 30 times per second and it cannot keep up with tight patters.

This: http://wn.com/moiré_effect
shows moiré on a shirt. Take 10 second look to get the idea.

This video shows a dozen examples of moiré in clothing and on objects.

http://www.youtube.com/watch?v=s5uu7C3OJw8&feature=player_embedded

8) Contrast
http://www.mediacollege.com/lighting/contrast-ratio/camera.html

Contrast is the range between the brightest and the darkest picture area that a video camera can reproduce. The contrast range for most NTSC video cameras is about 40:1. HDTV video cameras have much higher contrast ratios. That means that brightest picture area can only be 40X brighter than the darkest, or the camera will struggle to reproduce details in either the dark or the brightest area of the image. If a scene exceeds the limit, the cameraperson can pull down the brightest area, but this makes dark areas look like black blobs, or the cameraperson can choose to "pull up" the dark area, but this makes the brightest area "glow" or lose detail.

Shooting outdoors on a sunny day will exceed 40:1 and probably will exceed 100:1. To keep the ratio within the 40:1 range, you can use reflectors to bounce light into the shadow.

In studios, where you can control the lighting, the range is kept to 40:1.
You do want contrast. You don’t want the image blah! With everything in the same tonal range. You just don’t want extreme contrasting colors placed right next to each other.

The most common example of this is a person wearing a black suit and a perfectly white shirt. If the cameraperson balances so that the suit looks good and you can see the labels and lines, the shirt will blow out. It will almost glow like an angel. If the cameraperson balances so the shirt looks good, the suit will be a shapeless blob. What do you do? **DO NOT** wear a black suit with a white shirt. Do not let your talent wear a black suit with a white shirt. Do wear a black suit with a grey shirt, a cream shirt, a pastel shirt, a French blue shirt, etc.

**COLOR and Camera electronics:**

There are 3 basic color attributes: hue, saturation and brightness.

**Hue** is the color of an object. An apple is red. Hue is a part of the C channel of chrominance (chroma) channel in video.

**Saturation** is the richness or strength of a color. Saturation is the difference between a faded pair of blue jeans and a dark blue shirt. The dark blue jeans are much more saturated. Saturation is also part of the chroma or C channel.

**Brightness** is known as luminance in video. Luminance is how bright or how dark a scene is. Luminance is carried on the Y channel.

The chrominance (chroma) or C channel in a camera transports color signals.
The luminance or Y channel transports the B&W signal (black and white).

The C channel consists of 3 CCDs producing R,G,B light beams or electrical signals of varying strength. The combination of R,G,B in various strength or intensities creates all the colors you see on tv.

The Y channel carries the brightness info. It translates brightness variations in a scene into B&W pictures. More importantly, it gives color pictures crisp definition. Without luminance on the Y channel all the color images we see in video and on tv would be smeared images sort of like impressionistic art. For this reason, the Y signal is sampled more often than the C channel.

Monet (an impressionist painter)

The combination of the 3 CCD signals on the C channel and the Y signal = a composite NTSC signal. This is the signal that all regular American TV uses.