The first camcorder patent was issued to the prolific American inventor Jerome Lemelson in 1980. Lemelson, who passed away in 1997, had tried to patent the idea for a camcorder in 1977, but the U.S. Patent Office rejected him, claiming the idea was too far-fetched and that no company could ever be able to manufacture and sell the device. Among other things, Lemelson also invented crucial components for the VCR, Walkman, ATM and barcode scanner.
How images are recorded onto a digital camcorder

Camcorders contain 3 major components: lens, imager, and recorder. The lens gathers and focuses light on the imager. The imager (usually a CCD or CMOS sensor on modern camcorders; earlier examples often used vidicon tubes) converts incident light into an electrical (video) signal. Finally, the recorder encodes the video signal into a storable form. More commonly, the optics and imager are referred to as the camera section.

The lens is the first component in the camera-section's "light-path". The camcorder's optics generally have one or more of the following adjustments: aperture (to control the amount of light), zoom (to control the field-of-view), and shutter speed (to capture continuous motion.) In consumer units, these adjustments are automatically controlled by the camcorder's electronics, generally to maintain constant exposure onto the imager. Professional units offer direct user control of all major optical functions (aperture, shutter-speed, focus, etc.)

The imager section is the eye of the camcorder, housing a photosensitive device(s). The imager converts light into an electronic video-signal through an elaborate electronic process. The camera lens projects an image onto the imager surface, exposing the photosensitive array to light. The light exposure is converted into electrical charge. At the end of the timed exposure, the imager converts the accumulated charge into a continuous analog voltage at the imager's output terminals. After scan-out is complete, the photosites are reset to start the exposure-process for the next video frame. In modern (digital) camcorders, an analog-to-digital (ADC) converter digitizes the imager (analog) waveform output into a discrete digital-video signal.

The third section, the recorder, is responsible for writing the video-signal onto a recording medium (such as magnetic videotape.) The record function involves many signal-processing steps, and historically, the recording-process introduced some distortion and noise into the stored video, such that playback of the stored-signal may not retain the same characteristics/detail as the live video feed.

All but the most primitive camcorders imaginable also need to have a recorder-controlling section which allows the user to control the camcorder, switch the recorder into playback mode for reviewing the recorded footage and an image control section which controls exposure, focus and white-balance.
components of a camcorder

Digital and analog part ways fairly soon. The tiny silicon charge-coupled device (CCD) at the end of the lens barrel uses hundreds of thousands of pixels to make DV look incredibly sharp and clean, with around 500 lines of potential resolution (or more, in three-chip pro cameras).

From Analog to Digital
The circuit boards, do an enormous amount of the work of making your DV footage look and sound superior. The software coding and computer components contained in the boards produce a digital replica of each moment of video and audio in the analog-to-digital conversion process. There is also circuitry that works in reverse, for playback on your television. It's the "digital" part of DV that puts this technology head and shoulders above consumer analog video formats. Digital video is pure data, not analog signals, allowing pristine and endlessly repeatable transmission of high-resolution data through an all-digital pathway.

Doing the Math
All consumer digital video formats (Mini DV, Digital8, DVCAM and DVCPro) utilize the same basic data format and data rate (25Mbps) to encode and decode 29.97fps NTSC video data.
Components of a camcorder

Sampling: DV encoding hardware samples each frame of video for luminance (brightness) and chrominance (color) information. It uses 4:1:1 (Y:U:V or YUV) sampling for this operation. YUV signals are created from an original RGB (red, green and blue) source. The weighted values of R, G, and B are added together to produce a single Y signal, representing the overall brightness, or luminance, of that spot. The U signal is then created by subtracting the Y from the blue signal of the original RGB, and then scaling; V is created by subtracting the Y from the red, and then scaling by a different factor. The hardware scans each line of every 720x480 video frame, taking four pixel samples of luma information (Y) for every one pixel sample it takes of chroma information (U and V). That cuts down on extra data and also provides the right mix of luma and chroma detail to satisfy our eyes, which are more sensitive to brightness (luma) than color (chroma).

Compression: The DV brain then mathematically compresses each resampled frame of video to speed throughput and save storage space on tapes and hard drives. This is accomplished with a 5:1 DCT (discrete cosine transform) mathematical algorithm that discards as much unnecessary image information as possible while retaining much of the quality of the original image.

Audio: A separate sampling process takes the audio signal (after pre-amplification) and turns it into data as well. An audio sample rate of 48kHz (with a 16-bit depth per sample) produces a single track of high-fidelity digital stereo audio (2 channels). Alternately, a 32kHz sample rate with a 12-bit depth yields two stereo tracks (4 channels total), one of which can be used for voiceover narration.

Vital data: All of this pristine but compressed digital information is bundled with additional vital pieces of generated data. This information includes time code, time/date information and digital pilot tone signals to replace the conventional control track of analog video, which the DV format lacks.

Error correction: Also added to the data mix are error correction bits. Digital video data travels in tiny packets and the DV hardware adds unique codes that verify and correct corrupted data bits.

Express delivery: The whole package is finally bundled in data packets compliant with the DV standard. Every one of these packets - each the size of a single DV track - contains four independent regions: a subcode sector for time code and other data, a video sector, an audio sector and a sector for insert editing and track data. These packets move at a rate of 25Mbps (megabits per second), which translates to roughly 3.5MB of disk storage space per second of DV video.
components of a camcorder

Where the action is
The spinning drums that record data onto the tape and read it off. The drum that houses the heads is a polished metal cylinder that's angled in the cassette compartment and rotates at a very high rate. Rollers hold the tape against the drum's grooved surface, where a number of electromagnetic heads make slanted swipes across the surface of the tape, recording tracks of data that correspond exactly to the DV packets described previously.

Everything about this system is microscopic and is measurements are in microns, or thousandths of a millimeter. In fact, the record heads are so small, the tracks are so narrow and the data they contain is so densely packed, that a minute of digital video - about 200MB of information - occupies less than two meters of tape. Put another way, a DV cassette can hold about 13GB of digital information.

Digital Formats
Everything up to this point is common to the 25Mbps Mini DV (DV25), Digital8, DVCAM and DVCPro formats. When it comes to recording to tape, however, manufacturers have developed several different ways to store the data.

Mini DV tape comes in a 55mm wide plastic cassette to fit consumer camcorders. The tape itself is 6.35mm wide and is coated with metal that was deposited using an evaporated processing technique (ME). It moves at a rate of about 19mm per second, with a track width of 10 microns. The typical 60-minute Mini DV cassette is about 70m long and stores around 13GB of data. The closely-related standard DV tape (designed for use in VTRs) is the same tape format, but comes in a cassette that's twice as big and holds as much as 180 minutes of tape.

DVCAM (Sony) and DVCPro (Panasonic) formats are modified DV25 for the professional market. They use a wider track pitch for greater reliability and move the tape past the heads much faster. Both formats offer as much as three hours of running time on a single cassette.

The DVCPro format has several other pro-level features. DVCPro tapes use a metal particulate (MP) process instead of ME. Unlike Mini DV and DVCAM, DVCPro can use optional linear tracks at the top and bottom edges of the DV tape to record analog time code and audio information.

The Digital8 format also has idiosyncrasies. Larger than Mini DV tape, Digital8 records onto 8mm and Hi8 tape. The key difference is that in a Digital8 camcorder, the tape moves twice as fast as in its analog relatives, and the signal is digital. The Digital8 format is backward-compatible with the analog 8mm format.
A typical camcorder contains two basic parts:

* A camera section, consisting of a CCD (charge-coupled device), lens and motors to handle the zoom, focus and aperture

* A VCR section, in which a ‘typical’ TV VCR is shrunk down to fit in a much smaller space.

The camera component's function is to receive visual information and interpret it as an electronic video signal. The VCR component is exactly like the VCR connected to your television: It receives an electronic video signal and records it on video tape as magnetic patterns.
components of a camcorder

camcorder with the outer shell removed

camcorder's VCR unit
components of a camcorder
components of a camcorder

infrared autofocus mechanism

motors that focus the camera lenses
Like a film camera, a camcorder "sees" the world through lenses. In a film camera, the lenses serve to focus the light from a scene onto film treated with chemicals that have a controlled reaction to light. In this way, camera film records the scene in front of it: It picks up greater amounts of light from brighter parts of the scene, and lower amounts of light from darker parts of the scene. The lens in a camcorder also serves to focus light, but instead of focusing it onto film, it shines the light onto a small semiconductor image sensor. This sensor, a charge-coupled device (CCD), measures light with a half-inch (about 1 cm) panel of 300,000 to 500,000 tiny light-sensitive diodes called photosites.
Measuring light intensity only gives us a black-and-white image. To create a color image, a camcorder has to detect not only the total light levels, but also the levels of each color of light. Since you can produce the full spectrum of colors by combining the three colors red, green and blue, a camcorder actually only needs to measure the levels of these three colors to be able to reproduce a full-color picture.
The workings of a digital camera

Each photosite measures the amount of light (photons) that hits a particular point, and translates this information into electrons (electrical charges): A brighter image is represented by a higher electrical charge, and a darker image is represented by a lower electrical charge. Just as an artist sketches a scene by contrasting dark areas with light areas, a CCD creates a video picture by recording light intensity. During playback, this information directs the intensity of a television's electron beam as it passes over the screen.
In some high-end camcorders, a beam splitter separates a signal into three different versions of the same image -- one showing the level of red light, one showing the level of green light and one showing the level of blue light. Each of these images is captured by its own chip -- each measures the intensity of only one color of light. The camera then overlays these three images and the intensities of the different primary colors blend to produce a full-color image. A camcorder that uses this method is often referred to as a three-chip camcorder.
There are several ways of recording the three colors in a digital camera. The highest quality cameras use three separate sensors, each with a different filter. A beam splitter directs light to the different sensors. Think of the light entering the camera as water flowing through a pipe. Using a beam splitter would be like dividing an identical amount of water into three different pipes. Each sensor gets an identical look at the image; but because of the filters, each sensor only responds to one of the primary colors.

The advantage of this method is that the camera records each of the three colors at each pixel location. Unfortunately, cameras that use this method tend to be bulky and expensive.
Another method is to rotate a series of red, blue and green filters in front of a single sensor. The sensor records three separate images in rapid succession. This method also provides information on all three colors at each pixel location; but since the three images aren't taken at precisely the same moment, both the camera and the target of the photo must remain stationary for all three readings. This isn't practical for candid photography or handheld cameras.

Both of these methods work well for professional studio cameras, but they're not necessarily practical for casual snapshots.
This simple method produces a rich, high-resolution picture. CCDs are expensive and eat lots of power, so using three of them adds considerably to the manufacturing costs of a camcorder. Most camcorders get by with only one CCD by fitting permanent color filters to individual photosites. A certain percentage of photosites measures only levels of red light, another percentage measures only green light and the rest of the photosites measure only blue light. The color designations are spread out in a sort of grid (the Bayer filter below is a common configuration), so that the video camera computer can get a sense of the color levels in all parts of the screen. This method requires the computer to interpolate the true color of light arriving at each photosite by analyzing the information received by the other photosites in the vicinity.
The Lens
As mentioned previously, the first step in recording a video image is to focus light onto the CCD, using a lens.

To get a camera to record a clear picture of an object in front of it, you need to be able to adjust the focus of the lens -- that is, move the lens so it aims the light beams coming from that object precisely on the CCD. So, just like film cameras, camcorders let you move your lens in and out to focus light. Of course, most people need to move around with their camcorders, shooting many different things at different distances, and constantly refocusing is extremely difficult. This is why all camcorders come with an autofocus device, usually an infrared beam that bounces off objects in the center of the frame and comes back to a sensor on the camcorder.
components of a camcorder

To find the distance to the object, the processor calculates how long it takes the beam to bounce and return, multiplies this time by the speed of light, and divides the product by two (because it traveled the distance twice -- to the object and back again). The camcorder has a small motor that moves the lens, focusing it on objects at this distance. This works pretty well most of the time, but sometimes you have to override it -- you may want to focus on something in the side of the frame, for example, but the autofocus is picking up what's right in front of the camcorder.

Camcorders are also equipped with a zoom lens. In any sort of camera, you can magnify a scene by increasing the focal length of the lens (the distance between the lens and the film or CCD). An optical zoom lens is a single lens unit that lets you change this focal length, so you can move from one magnification to a closer magnification. A zoom range tells you the maximum and minimum magnification. To make the zoom function easier to use, most camcorders have an attached motor that adjusts the zoom lens in response to a simple toggle control on the grip. One advantage of this is that you can operate the zoom easily, without using your free hand. The other advantage is that the motor adjusts the lens at a steady speed, making zooms more fluid. The disadvantage of using the grip control is that the motor drains battery power.

Some camcorders also have something called a digital zoom. This doesn't involve the camera's lenses at all; it simply zooms in on part of the total picture captured by the CCD, magnifying the pixels. Digital zooms stabilize magnified pictures a little better than optical zooms, but you sacrifice resolution quality because you end up using only a portion of the available photosites on the CCD. The loss of resolution makes the image fuzzy.

One of the great things about a camcorder is that it can adjust automatically for different levels of light. It's very obvious to the CCD when an image is over- or under-exposed because there isn't much variation in the charges collected on each photosite. The camcorder monitors the photosite charges and adjusts the camera's iris to let more or less light through the lenses. The camcorder computer always works to maintain a good contrast between dark and light, so that images don't appear too dark or too washed out.
A third component, the viewfinder, receives the video image as well, so you can see what you're shooting. Viewfinders are actually small, black-and-white or color televisions, most modern camcorders also have larger full-color LCD screens.

Digital camcorders have these elements, and an added component that takes the analog information the camera gathers and translates it to bytes of data. Instead of storing the video signal as a continuous track of magnetic patterns, it records the picture and sound as 1s and 0s. Digital camcorders can copy 1s and 0s very easily without losing any of the information you've recorded.
Digital Video (DV) is a digital video format launched in 1996. MiniDV camcorders record on compact cassettes, which are fairly inexpensive and hold about 60 to 90 minutes of footage. The video has an impressive (approx.) 500 lines of resolution, and can be easily transferred to a personal computer. The DV specification (originally known as the Blue Book, current official name IEC 61834) defines both the codec and the tape format. Features include intraframe compression for uncomplicated editing, a standard interface for transfer to non-linear editing systems (IEEE 1394, also known as FireWire).

A codec is a device or program capable of performing encoding and decoding on a digital data stream or signal. The word codec may be a combination of any of the following: 'compressor-decompressor', 'coder-decoder', or 'compression/decompression algorithm'. Before arriving at the codec compression stage, light energy hitting the sensor is transduced into analog electrical signals. These signals are then converted into digital signal by an analog to digital converter (ADC or A/D). This signal is then processed by a digital signal processor (DSP) or custom ASIC and undergoes different processes - for example, processing of raw input into (linear) RGB signals - for Bayer pattern-based sensors (i.e. sensors utilizing a single CCD or CMOS and color filters), the raw input has to be demosaiced.

Programs such as TLC’s Trauma: Life in the E.R. and ABC News’ Hopkins: 24/7 were shot on DV. CNN’s Anderson Cooper is perhaps the best known of the generation of reporter/videographers who began their profession careers shooting their own stories.
When a tape is being recorded on, or played back, it moves at almost 18.9 mm a second past a drum rotating at 9000 rpm. The drum contains recording/playback heads and its angled so the heads can read and write data tracks diagonally across the tape, a process called helical scanning.

An NTSC camera will lay down 10 tracks for one frame of NTSC video, and a PAL camera 12, all in a space the width of a human hair. These tracks contain the video, audio, and data the camcorder uses to manage and keep track of everything.

The recorded video (or data) is essentially a continuous stream of 1's and 0's. An electrical voltage corresponding to those 1's and 0's gets stored into the magnetic material on the Mini DV tape. When you play the video back, the magnetic patterns reproduce an equivalent electrical signal turning all of those 1's and 0's into moving pictures.

Since it is digital, any voltage variation above a certain high value is recognized as "1" and any voltage variation below a minimum value is recognized as a "0". Once the digital values are recognized, they are "regenerated" (ie. you get a value of say 5V instead of your actual 500uV from playback head and you get a value of say 0.2V instead of the actual 50uV from playback head).

What happens when you overwrite? When you record over old footage, older values are overwritten with the new data (new magnetization). There could also be an erase head which tends to cleanup the tape before recording (this is sometimes not added in to reduce the cost of the camera since digital data does not need a clean demagnetized tape for recording).

So, what you will see now as new voltage from the actual playback head could be say 475uV on places where the previous data was a "0" and close to 500uV when the old data is "1", when the overwitten data is "1". You could similarly figure out the voltage level for previous data with value of "0" overwritten by a "0" or "1".

But the problem here is that the output circuit from the player "regenerates" the value if it is above or below a certain threshold say whatever voltage above 400uV is output as 5V and whatever value less than 100uV is output as 0.2V. The situation becomes even more complex as you overwrite the data multiple times - thus it is not recommended.

The main problem with DV tapes and the compounds they use to lubricate the tapes. The lubricants from different brands can accumulate on the heads and react with each other. This gums up the heads and messes up a lot of transfers.
DV allows either 2 digital audio channels (usually stereo) at 16 bit resolution and 48 kHz sampling rate, or 4 digital audio channels at 12 bit resolution and 32 kHz sampling rate. For professional or broadcast applications, 48 kHz is used almost exclusively. In addition, the DV spec includes the ability to record audio at 44.1 kHz (the same sampling rate used for CD audio), although in practice this option is rarely used. DVCAM and DVCPRO both use locked audio while standard DV does not. This means that at any one point on a DV tape the audio may be +/- ½ frame out of sync with the video. However, this is the maximum drift of the audio/video sync; it is not compounded throughout the recording. In DVCAM and DVCPRO recordings the audio sync is permanently linked to the video sync.
There are two parts to any audio magnetic recording system: the recorder itself (which also acts as the playback device) and the tape it uses as the storage medium.

The tape itself is actually very simple. It consists of a thin plastic base material, and bonded to this base is a coating of ferric oxide powder. The oxide is normally mixed with a binder to attach it to the plastic, and it also includes some sort of dry lubricant to avoid wearing out the recorder.

Iron oxide (FeO) is the red rust we commonly see. Ferric oxide (Fe2O3) is another oxide of iron. Maghemite or gamma ferric oxide are common names for the substance.

This oxide is a ferromagnetic material, meaning that if you expose it to a magnetic field it is permanently magnetized by the field. That ability gives magnetic tape two of its most appealing features:

* You can record anything you want instantly and the tape will remember what you recorded for playback at any time.
* You can erase the tape and record something else on it any time you like.

These two features are what make tapes and disks so popular -- they are instant and they are easily changed.

Audio tapes have gone through several format changes over the years.

* The original format was not tape at all, but actually was a thin steel wire. The wire recorder was invented in 1900 by Valdemar Poulsen.
* German engineers perfected the first tape recorders using oxide tapes in the 1930s. Tapes originally appeared in a reel-to-reel format.
* Reel-to-reel tapes were common until the compact cassette or "cassette tape" took hold of the market. The cassette was patented in 1964 and eventually beat out 8-track tapes and reel-to-reel to become the dominant tape format in the audio industry.
A Transistor, an incredible invention of the last century, electrically produces binary digits. A transistor can only turn electricity on, which is equal to one, and off which is equal to zero. A basic digital code is as follows: 00001010. This is how computers represent all information, with more complex codes for more complex pieces of information. A song or an image, such as a movie, can contain literally millions of these small bits of code or information. The information is stored as a binary digit of a 0 and 1. These binary digit codes are then burned, using a laser beam, into the chemical layer of a CD-ROM. On a Floppy drive disk, small magnetic iron particles are realigned in such a way so they can store the information also as a 1 and 0.

Sound recorded from a microphone originates as an analog signal. This is true for even your computer microphone. The computer uses a component called a digital to analog converter named a DAC, and an analog to digital converter, ADC. If you want to record your voice through your computer's microphone, as you speak the ADC works to store the waveform sound into a digital format. When you play music back on the computer the DAC works to transform the digital 1 and 0 to a waveform that can be heard on your speakers.

The storage medium for an analog signal is generally a ribbon or tape. The recording tape has a covering of small iron particles on the surface. These particles resemble very small compasses with all of the little needles pointing in some random direction. When a magnetic field passes across the tape, such as the recording head in a VCR or cassette tape recorder, the iron particles realign. This realignment of the small particles actually stores the waveform of the sound. This transfer is identical to the sound made through a microphone. Analog signals transfer in their original state as a waveform to magnetic tape. These waveform signals are easy to alter in their intensity by adjusting the volume and tone. The waveform is the same as when you speak into the microphone, and the recording head realigns the iron particles on the tape to store the information.