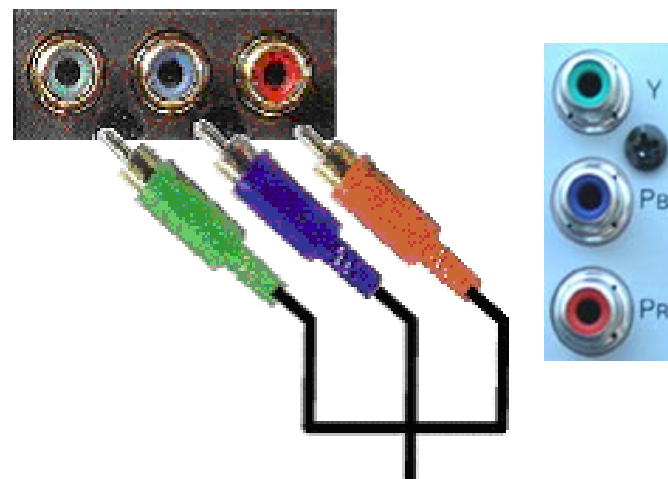
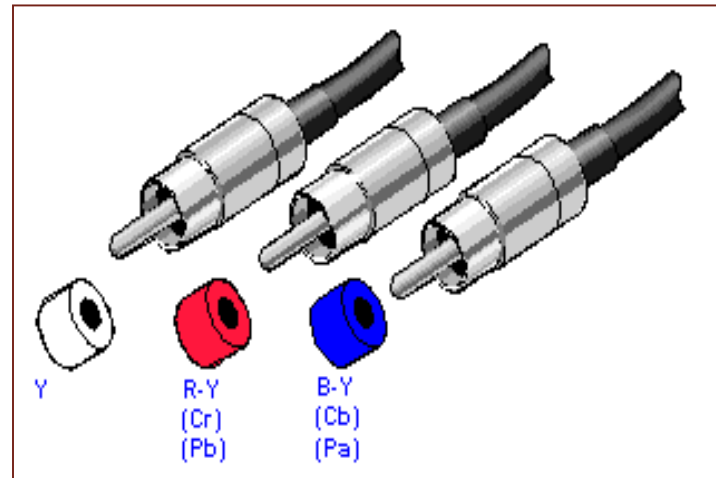


# Fundamental Concepts in Video

- Types of Video Signals
- Analog Video
- Digital Video
- Video Processing Techniques
- Further Exploration

# Component video — 3 signals

- Higher-end video systems make use of three separate video signals for the red, green, and blue image planes.
- Most computer systems use Component Video, with separate signals for R, G, and B signals.
- For any color separation scheme, Component Video gives the best color reproduction since there is no “crosstalk” between the three channels, unlike S-Video or Composite Video.
- Component video requires more bandwidth and good synchronization of the three components.



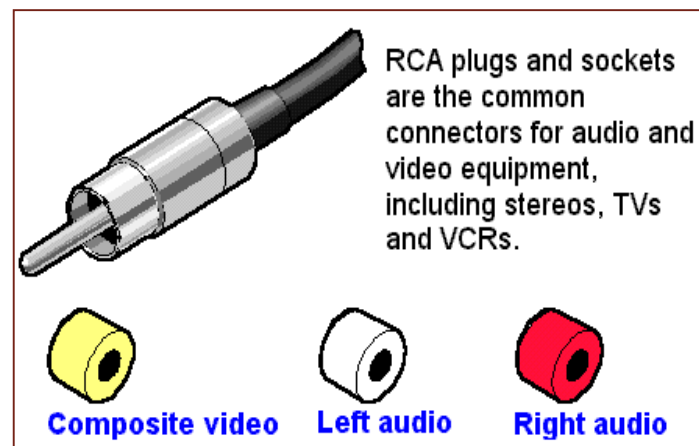
# S-Video — 2 Signals

- Also known as Separated Video, or Super-video
- S-Video uses two wires, one for luminance and another for a composite chrominance signal.
  - The grayscale information is most crucial for visual perception.
  - Humans are able to differentiate spatial resolution in grayscale images much better than for the color part of color images.
  - Less crosstalk between the color information and the grayscale information
- S-video provides a sharper image than composite video, but is not as good as component video.



# Composite Video — 1 Signal

- Color (“chrominance”) and intensity (“luminance”) signals are mixed into *a single carrier* wave.
- The chrominance and luminance components can be separated at the receiver end and then the color components can be further recovered.
- When connecting to TVs or VCRs
  - Composite Video uses only one wire.
  - Video color signals are mixed, not sent separately.
  - The audio and *sync* signals are additions to this one signal.
- Since color and intensity are wrapped into the same signal, some interference between the luminance and chrominance signals is inevitable.



# 4.2 Analog Video

- An analog signal  $f(t)$  samples a time-varying image.
- Two type of scanning
  - *Progressive scanning*
    - traces through a complete picture (a frame) row-wise for each time interval.
    - A HD computer monitor typically uses a time interval of  $1/72$  second.
  - Interlaced scanning
    - is used in TV and in some monitors and multimedia standards.
    - reduces perceived flicker since it was difficult to transmit the amount of information in a full frame quickly.



**Progressive Scan  
(Non-interlaced)**

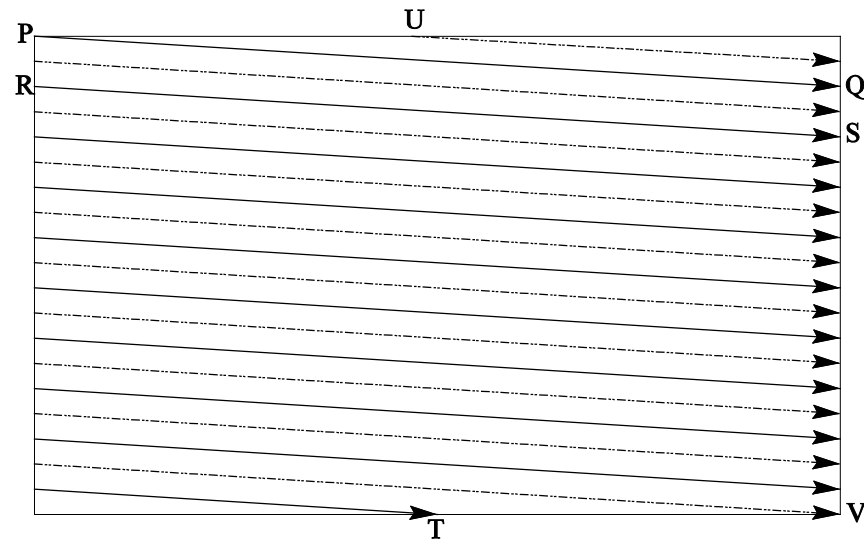
# Interlaced scanning

- The odd-numbered lines are traced first, and then the even-numbered lines are traced.
- This results in “odd” and “even” fields — two fields make up one frame.
- In fact, the odd lines (starting from 1) end up at the middle of a line at the end of the odd field, and the even scan starts at a half-way point.



Interlaced

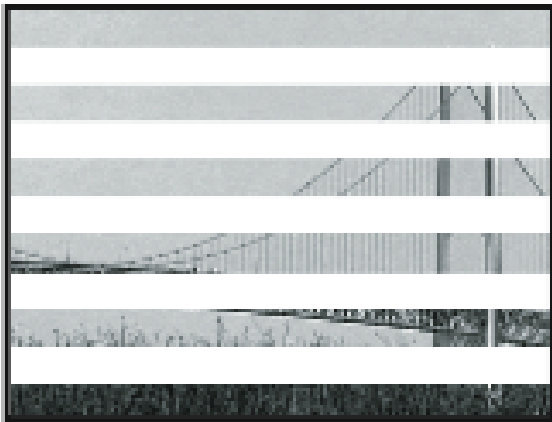
# Interlaced scanning



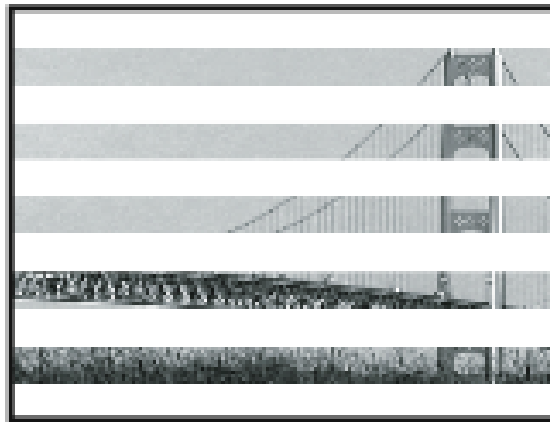
- The solid (odd) lines are traced, P to Q, then R to S, ..., ending at T. The even field starts at U and ends at V.
- Horizontal retrace-the jump from Q to R, etc.
- Vertical retrace-the jump from T to U or V to P, etc.



# Interlaced scanning



Field 1 is sampled first and contains only the odd lines.



Field 2 sampled 1/60th of a second later contains the even-lines.



A complete frame consists of field 1 and field 2.

# Interlaced scanning

- The odd and even lines are displaced in time from each other
  - Generally not noticeable except when very fast action is taking place on screen, when blurring may occur.



- In the video in Fig. 4.2, the moving helicopter is blurred more than the still background.

# Interlaced scanning



(a) The video frame



(b) Field 1



(c) Field 2



(d) Different of Fields

- De-interlacing
  - Is used to change the frame rate, resize, or produce still images from an interlaced source video.
  - The simplest de-interlacing method consists of discarding one field and duplicating the scan lines of the other field. The information in one field is lost completely using this simple technique.
- Define the beginning of a new video line
  - Voltage is one dimensional signal that varies with time.
  - Analog video use a small voltage offset from zero to indicate “black”, and another value such as zero to indicate the start of a line. Namely, we could use a "blacker-than-black" zero signal to indicate the beginning of a line.

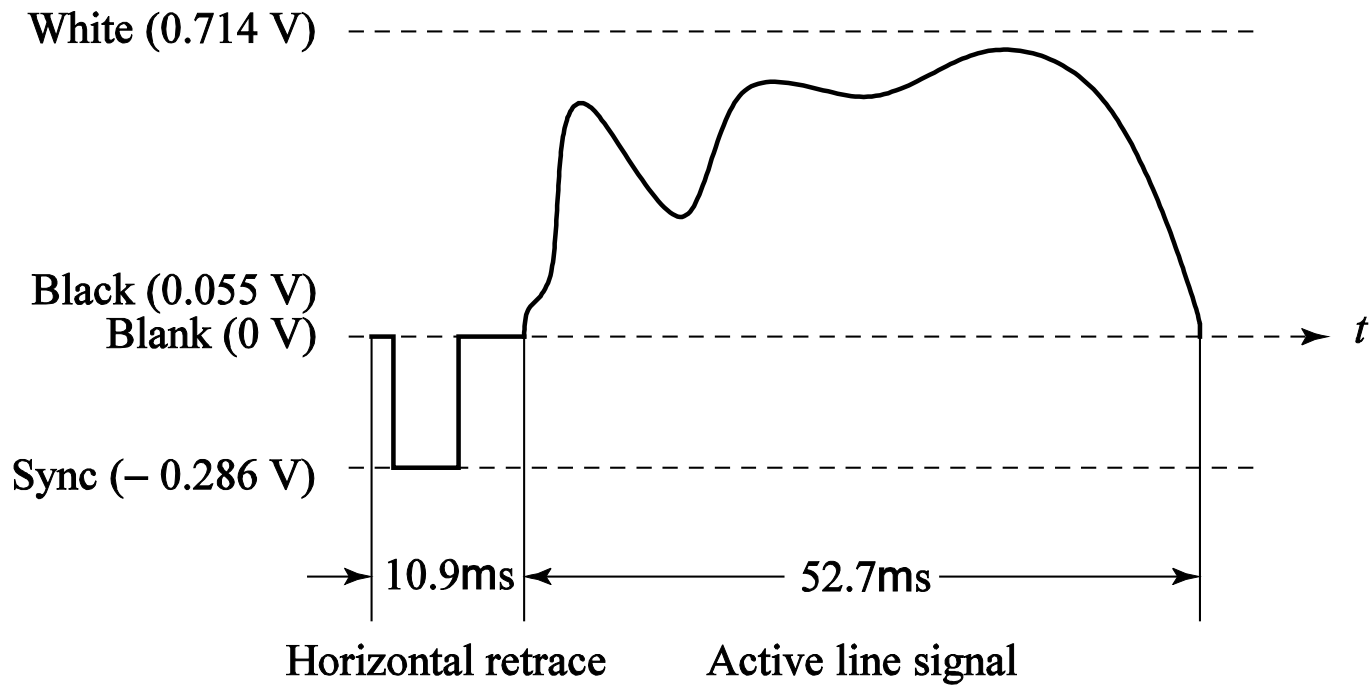


Figure. Electronic signal for one NTSC scan line.

## 4.3 Digital Video

- Some advantages:
  - Storing video on digital devices or in memory, ready to be processed (noise removal, cut and paste, etc.), and integrated to various multimedia applications.
  - Direct access, which makes nonlinear video editing simple.
  - Repeated recording does not degrade image quality.
  - Ease of encryption and better tolerance to channel noise.

# Digital Video connectors

- Digital Video connectors are used to deliver the highest quality video signal. The technology uses TMDS (Transition Minimized Differential Signaling) to transmit large amounts of digital data from the source to the display, resulting in a high-quality image.
- DVI (Digital Visual Interface) was developed by the industry body DDWG (the Data Display Working Group) to send digital information from a computer to a digital display, such as a flat-panel LCD monitor.
- HDMI took a step forward by integrating audio and video into a more compact interface.
- DisplayPort is an interface technology that is designed to connect high-graphics capable PCs and displays as well as home theater equipment and displays. DisplayPort is similar to HDMI in that the DisplayPort signal carries both digital audio and video.

# DVI - Digital Visual Interface

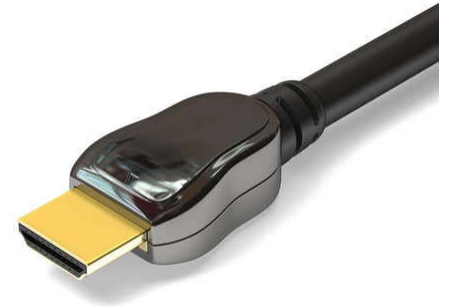
- DVI is a video display interface that is used to connect a video source to a display device, such as a computer monitor. It was developed with the intention of creating an industry standard for the transfer of digital video content.
- This interface is designed to transmit uncompressed digital video and can be configured to support multiple modes such as DVI-A (analog only), DVI-D (digital only) or DVI-I (digital and analog). Featuring support for analog connections, the DVI specification is compatible with the VGA interface.
- Although DVI is predominantly associated with computers, it is sometimes used in other consumer electronics such as television sets and DVD players.





# HDMI - High Definition Multimedia Interface

- HDMI stands for High Definition Multimedia Interface.
- This technology carries the same video information as DVI but adds the capacity for digital audio and control signals as well.
- Found on many home theater/consumer electronics devices, HDMI uses a 19-pin connector that is held in place by friction.



**HDMI**™  
HIGH-DEFINITION MULTIMEDIA INTERFACE

# DisplayPort



- DisplayPort is an interface technology that is designed to connect high-end graphics capable PCs and displays as well as home theater equipment and displays.
- Like HDMI and DVI, DisplayPort utilizes TMDS (Transition Minimized Differential Signaling) link technology to send high bandwidth video and audio signals.
- The 20-pin connector allows the contact point to send maximum data transfer rates of 8.64 Gbps plus 1 Mbps for its AUX channel which can carry additional data.



# HDTV (High Definition TV)

- High Definition Television (HDTV) is video that has resolution substantially higher than that of traditional television systems (standard-definition TV, or SDTV, or SD).
- HDTV has one or two million pixels per frame, roughly five times that of SD.
- Early HDTV broadcasting used analog techniques, but today HDTV is digitally broadcast using video compression.

- The standard supports video scanning formats shown in Table below, where “I” mean interlaced scan and “P” means progressive (non-interlaced) scan.

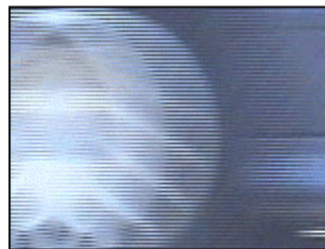
- Table 1. Advanced Digital TV formats

# of Active Pixels per line	# of Active Lines	Aspect Ratio	Picture Rate
1,920	1,080	16:9	60I 30P 24P
1,280	720	16:9	60P 30P 24P
704	480	16:9 & 4:3	60I 60P 30P 24P
640	480	4:3	60I 60P 30P 24P

- For video, *MPEG-2* is the compression standard.
- For audio, *AC-3* is the standard. It supports the so-called 5.1 channel Dolby surround sound, i.e., five surround channels plus a subwoofer channel.
- The salient difference between conventional TV and HDTV:
  - HDTV has a much wider aspect ratio of 16:9 instead of 4:3. (1/3 wider)
  - HDTV moves toward progressive (non-interlaced) scanning. The rationale is that interlacing introduces serrated edges to moving objects and flickers along horizontal edges.



progressive scan



interlace



progressive scan



interlace

- The FCC has planned to replace all analog broadcast services with digital TV broadcasting. The services provided include:
  - **SDTV (Standard Definition TV)**: the current NTSC TV or higher.
  - **EDTV (Enhanced Definition TV)**: 480 active lines or higher, i.e., the third and fourth rows in Table 1.
  - **HDTV (High Definition TV)**: 720 active lines or higher.
  - Popular choices:
    - 720p (720 lines, progressive, 30fps)
    - 1080I(1080 lines,interlaced,30fps or 60fps)

# Data Rate and Video Storage Size

- Calculate the data rate in **bps** (bits per second) and storage requirement in **bytes** for a one-hour grayscale video with 800 X 600 frame size and 24 fps (frames per second) frame rate.
- $\text{Data rate} = \text{Resolution} * \text{Bits per pixel} * \text{Frame rate}$
- $\text{Storage size} = \text{Data rate} * \text{Time}$

## 4.4 Video Processing Techniques

- This section mainly discusses how animation can be produced with the help of computers.
- Other processing techniques, such as video compression and transmission, will be discussed in another course “Digital Image and Video Processing” in year 4.



# Image Sequences

- Animation is the creation of moving pictures, one frame at a time.
- Traditional animators have developed many techniques, including [cel animation](#), [stop motion](#) and [claymation](#).

# Traditional Animation

- Cel animation (classical animation or hand-drawn animation)
  - The oldest and historically the most popular form of animation.
  - Each frame is drawn by hand.
  - In contrast with the more commonly used computer animation nowadays.

<https://conceptartempire.com/cel-animation/>

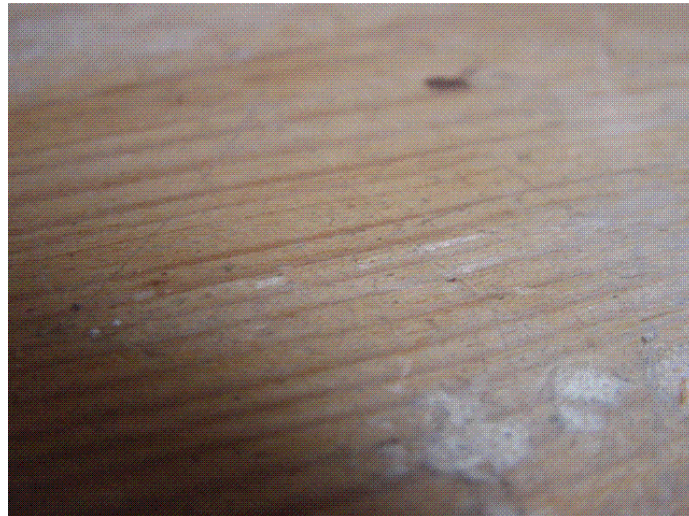


A horse animated from Eadweard Muybridge's 19th century photos. The animation consists of 8 drawings, which are "looped", i.e. repeated over and over. This example is also "shot on twos", i.e. shown at 12 frames per second. (24fps)

# Traditional Animation

- Stop motion (stop action or frame-by-frame)
  - An animation technique to make a physically manipulated object appear to move on its own.
  - The object is moved in small increments between individually photographed frames, creating the illusion of movement when the series of frames is played as a continuous sequence.

A simple stop motion animation of a moving coin.

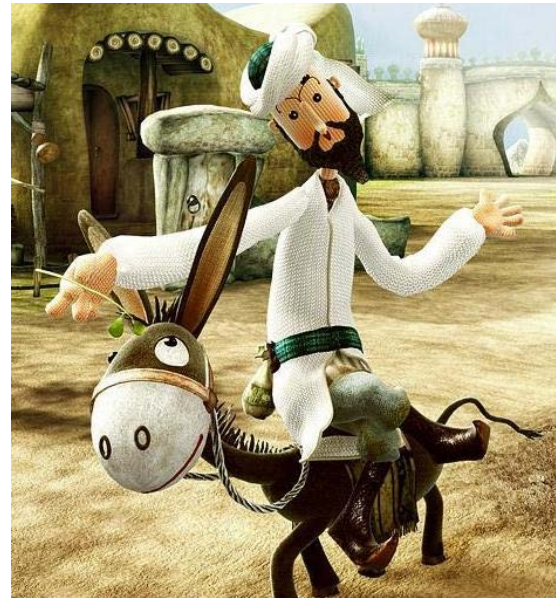


# Traditional Animation

- Claymation (or clay-animation)
  - One of many forms of stop motion animation.
  - Each animated piece, either character or background, is "deformable" — made of a malleable substance, usually Plasticine clay.



Wallace and Gromit



A clay animation scene from “A Fan Ti”.

# Image Sequences

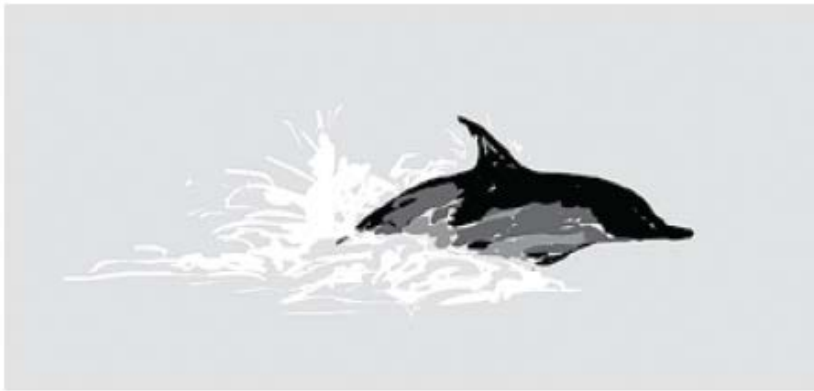
- Traditional animation can be captured one frame at a time using a camera connected to a computer, instead of being recorded on film.
- Animation can be created digitally.
- Individual frames can be created in a graphics program.
- Using layers to represent the contents of a frame can streamline the animation process.
- A sequence of images can be stored in consecutively numbered image files, which can be imported into video editing programs such as Flash.

# Image Sequences

- An animation is a sequence of frames, each one a still image.
- Either bitmapped images or vector graphics can be used for the individual frames.
  - Vector graphics offer more possibilities for creating and manipulating frames using computer programs.
  - Bitmapped images are conceptually simpler, though, and correspond more closely to the traditional animations consisting of a sequence of photographed images on film.

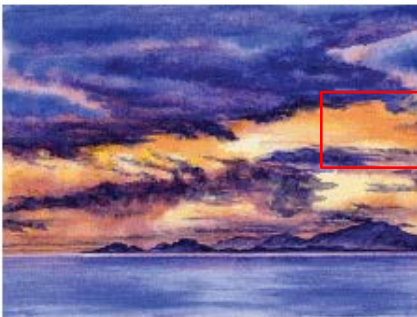
# Image Sequences

- An animated GIF contains multiple bitmapped images in a single file.
- The individual images can be displayed in sequence by Web browsers and other programs, without plug-in.
- GIFs are only suitable for short simple animations.
- GIFs use indexed color and lossless intra-frame compression, whose effectiveness depends on the nature of the images in the animation.
- GIFs cannot have a soundtrack or player controls.



*Original (top) and animated GIF (bottom) frames,  
suitable material*





*Original (top) and animated GIF (bottom) frames,  
unsuitable material*

# Interpolation

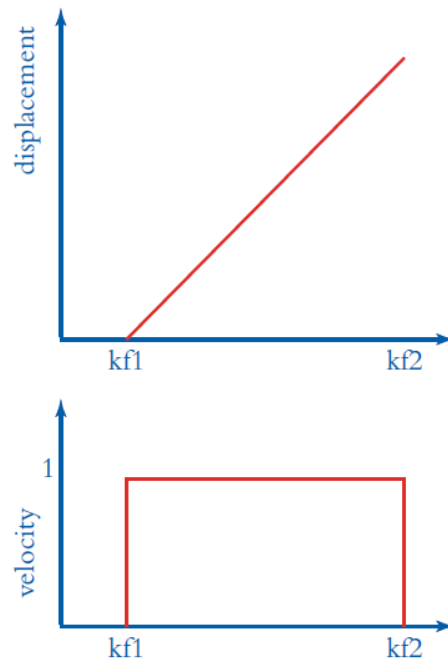
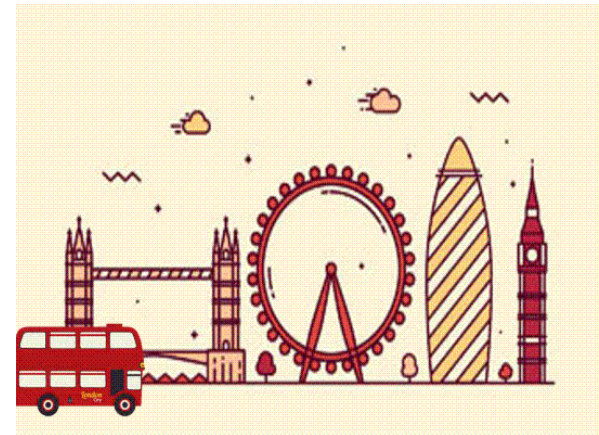
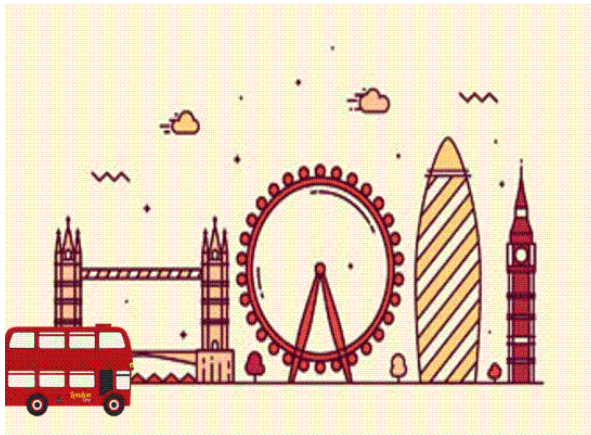
- In traditional animation, chief animators draw key frames at important points; in-betweeners create intervening frames.
- Interpolation: the calculation of values lying between known points.
- Animation programs perform equivalent in-betweening by interpolating the values of properties such as position between key frames.
- Interpolation can be applied to layers in bitmapped images or to properties of vector objects.

# Interpolation

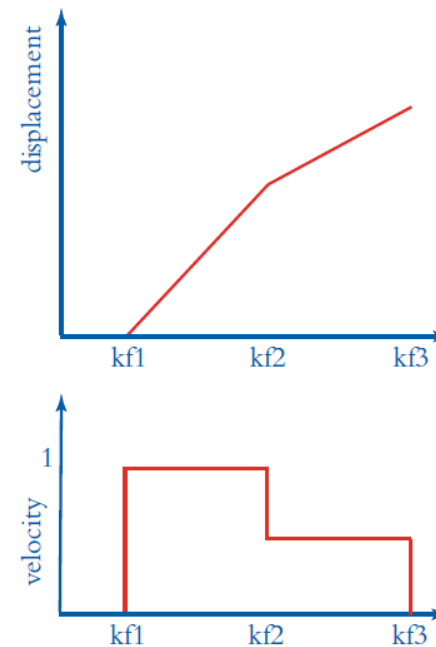
- Bitmaps do not contain identifiable objects
  - Use layers to isolate different elements of an animation if we wish to change them independently.
- Vector animations, we do have identifiable objects, and their properties are represented entirely numerically.
  - Makes interpolating the position, size, color and other properties of vector objects conceptually and practically easier.

# Interpolation

- Walt Disney developed a mass production approach to animation.
- Disney's approach create animations relied on breaking down the production of a sequence of drawings into sub-tasks.
- If motion is interpolated linearly, movement begins and ends instantaneously. And there may be unnatural discontinuities between interpolated sequences.



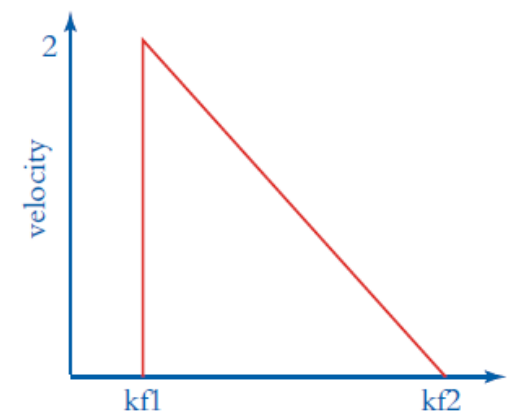
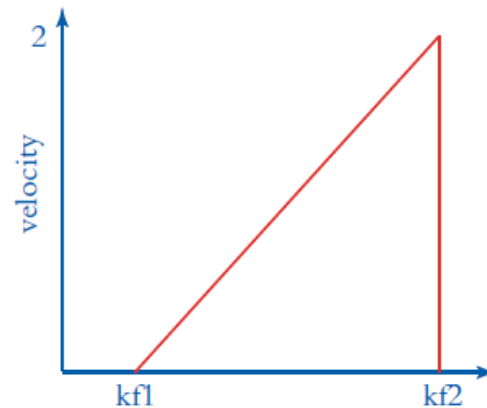
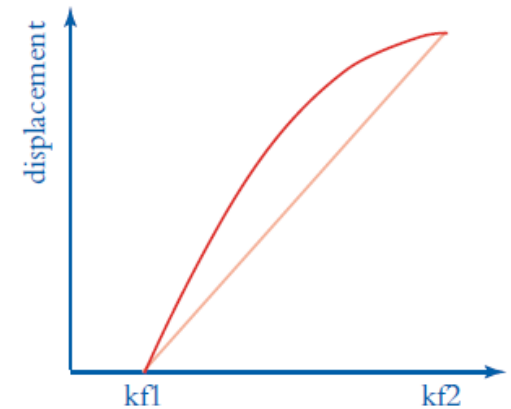
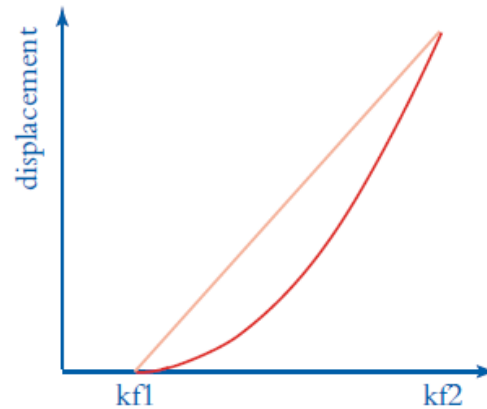
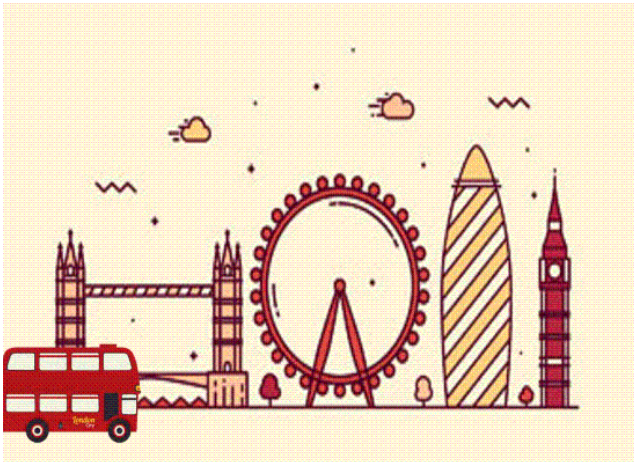
*Linearly interpolated motion*



*Abrupt change of velocity caused by linear interpolation*

# Interpolation

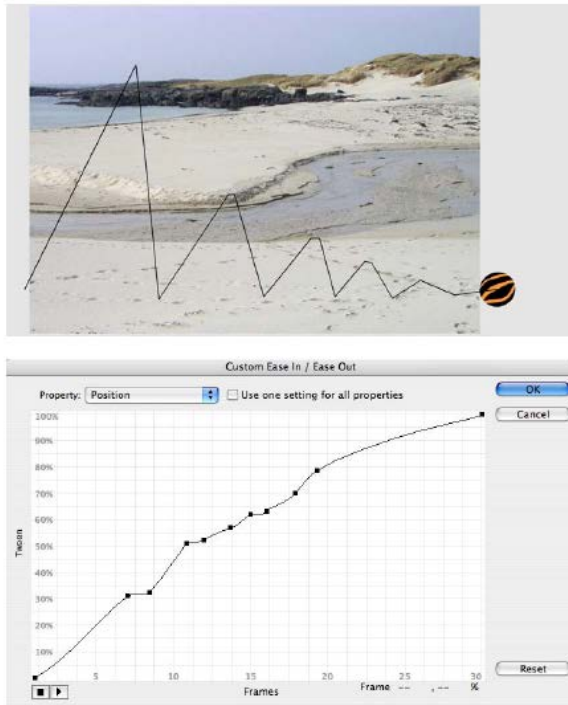
- Easing in and out can be used to cause the motion to increase or decrease gradually.



*Quadratic easing in (left) and out (right)*

# Interpolation

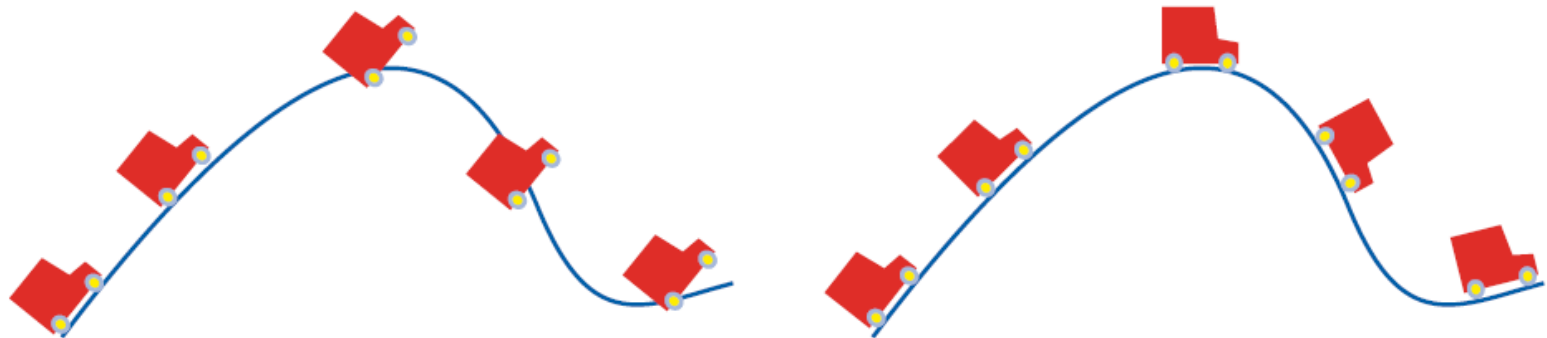
- Custom easing using Bézier curves is used to control the rate of change in arbitrarily complex ways.



*Interpolating motion along a path with custom easing*

# Interpolation

- Objects or layers can be made to move along motion paths.
- When using motion paths, it is usually necessary to orient the moving object to the path to achieve a realistic effect.

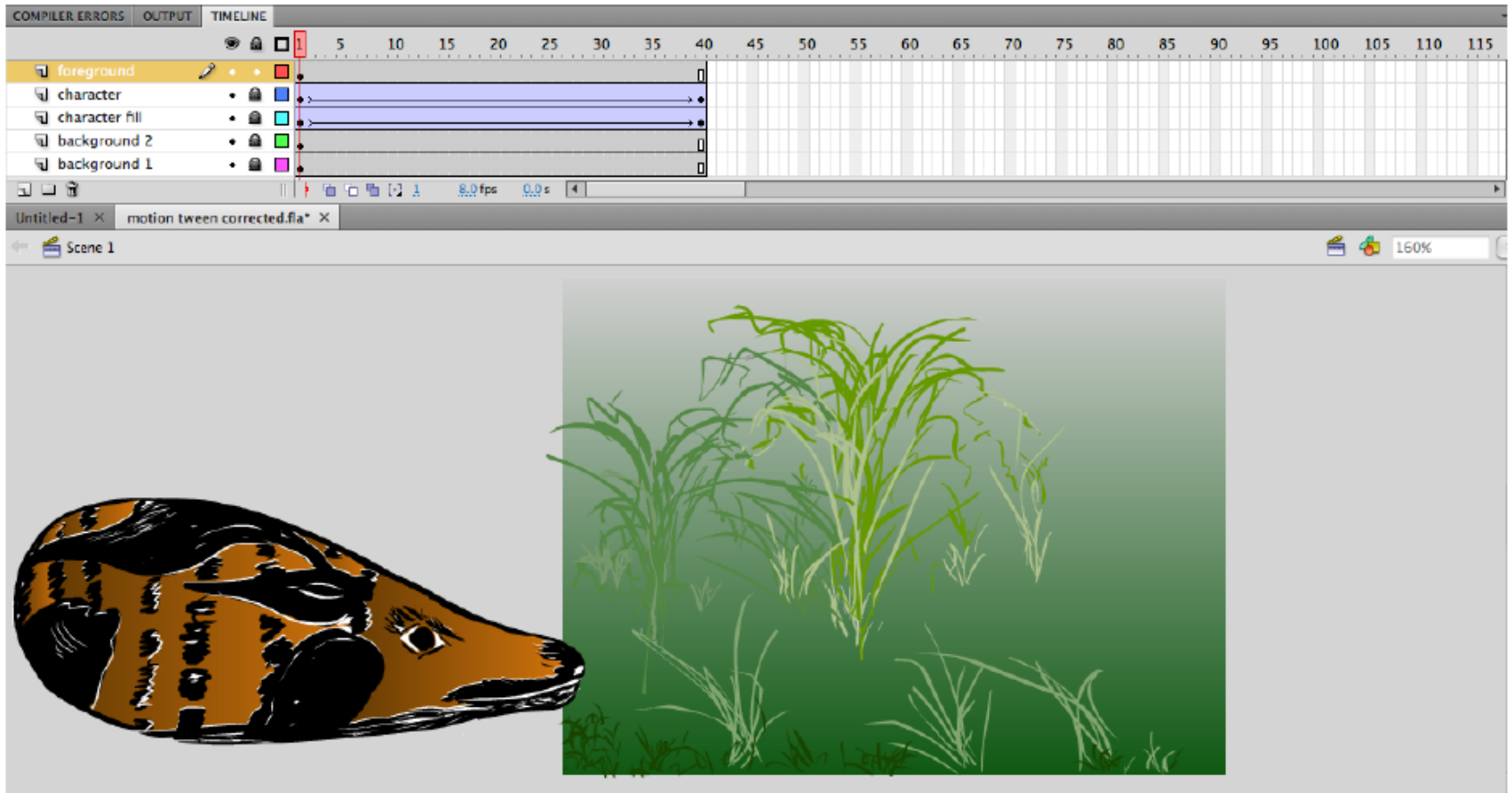


*Fixed orientation (left) and orientation to the motion path (right)*



# Vector Animation

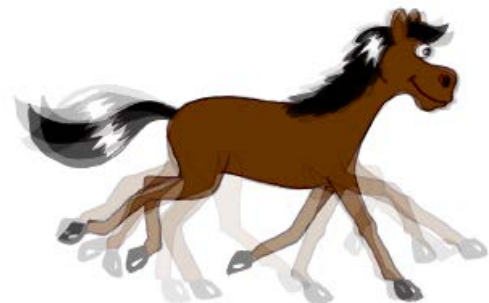
- Flash movies, also known as SWF files, a popular Web animation format. They are usually created in Flash, but SWFs may also be exported from other programs.
- An animation being created in Flash is organized using a timeline.
- The vector objects used in the animation are created on the stage, using conventional vector drawing tools and techniques.



*The timeline (top) and stage (below) in a simple Flash movie*

# Vector Animation

- Onion-skinning can be used to help align and change objects in consecutive frames.
- Key frames are drawn in their entirety on the stage.
- Ordinary frames have no content, they just hold the picture from the preceding key frame.



# Vector Animation

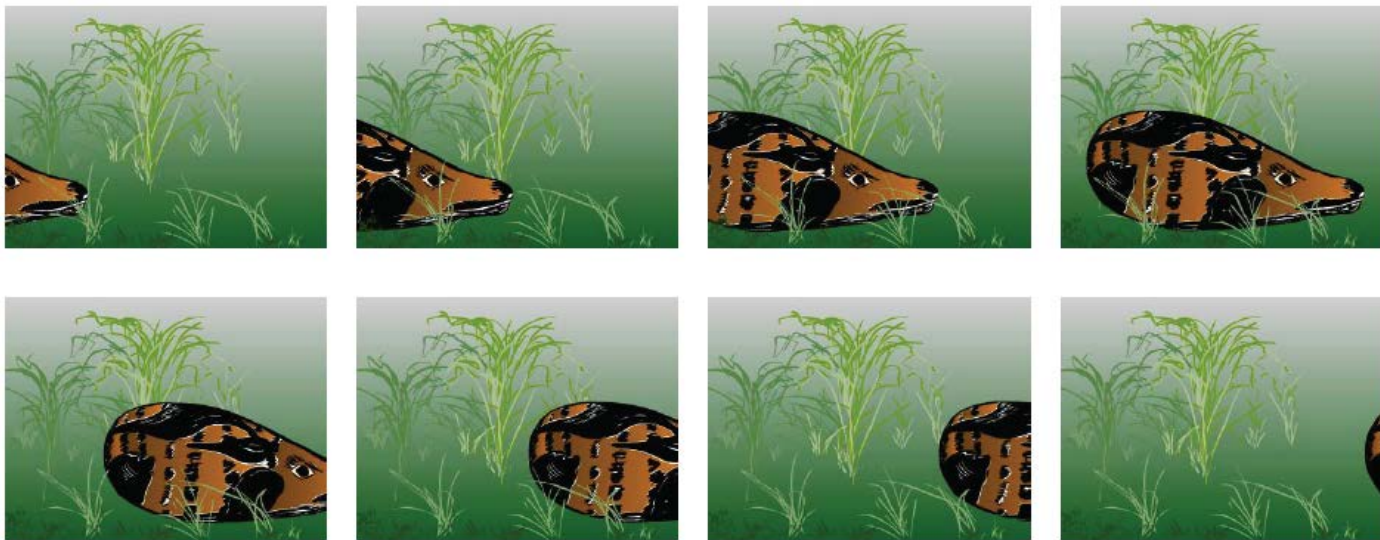
- Graphical objects can be stored in a library as **symbols**.
- Instances of symbols can be created on the stage, allowing objects to be reused.
- Instances can be transformed independently and have different visual effects applied to them.



*Instances of a symbol*

# Vector Animation

- Interpolation (“tweening”) is applied to symbol instances.
- Easing can be applied to tweened motion.
- An object’s size, orientation, opacity and color may also be interpolated.



*Simple tweened motion of a symbol instance*

# Vector Animation

- Shape tweening (“morphing”) is used to transform one shape into another.



# 4.5 Further Exploration

<http://www.cs.sfu.ca/mmbook/> Further Exploration-Chapter5

- Tutorials on NTSC television
- The latest news on the digital TV front
- Introduction to HDTV
- Adobe Flash Software