A GLOSSARY OF ANIMATION TERMS

Hand drawn and digital animation has its own vocabulary. Here are some 2D and 3D animation terms you may encounter. Let me know if there is anything I should add (cyonge@ucsc.edu)

**Albedo**
A measure (from 0, completely black, to 1, fully white) of the brightness of a surface. Generally used in astronomy, this is coming into use in computer graphics as reference to surface (diffuse) color in PBR.

**Alpha channel**
Computer images have three or four color channels, which are grayscale images representing the intensity of colored ink or light at particular places on the screen. These are RGB (Red-Green-Blue) for work that is intended to be shown by light emitting media such as monitors or projectors, and CMYK (Cyan-Magenta-Yellow-Black) for light absorbing media such as printed paper. An alpha channel is only needed for an RGB image and is an additional channel that describes transparency; this is needed for combining layers of images in post processing.

**Ambient occlusion (or AO)**
In 3D animation, a simple means of lighting a 3D scene based not on light but on shadows. An AO lit scene assumes even illumination from every part of a hemisphere surrounding the objects and calculates how much illumination should be removed based on what other parts of the scene shadow the element being rendered. A pixel in the final image that represents the top of a tall cone in the scene will see almost all of the surrounding hemisphere and be lit the brightest. A pixel representing part of face in a deep cave facing the camera will see a tiny fraction of the surrounding hemisphere and be lit the least. Too much AO will look flat and uninteresting, but it is a fast way to start lighting a scene before adding directional light.

**Anisotropy**
The quality of a material that shapes and angles its highlights - brushed metal is the best example of this.

**Anti-aliasing**
A computer rendering post processing technique that changes the color of some image pixels defining a sharp inclined edge so that it looks less jagged or “stair stepped”. The color change in each pixels of the anti-aliased image depends on the number of surrounding pixels sampled and the two colors involved. Anti-aliasing against a transparent background also involves varying degrees of transparency in the relevant pixels and needs at least an 8-bit alpha channel in the image format.
Aspect ratio
The proportion of width to height of an image or video/animation. There is an excellent history of aspect ratio in the cinema and television at [http://youtu.be/3CgrMsjGk7k](http://youtu.be/3CgrMsjGk7k). The whole Filmmaker IQ YouTube channel is worth seeing if you’re interested in learning about cinema history, technology, and technique.

Armature
Available in 3D (and some 2D, such as Flash) animation software, this is an arrangement of links called “bones” (which can be rigid or flexible) that make up the equivalent of a skeleton. Each bone influences, through weight painting, the way its movement moves nearby vertices. The complex process of making and adjusting an armature to animate a mesh is known as rigging and is a distinct specialism in the animation industry. An armature can also be a jointed metal core used by stop motion animators such as the one shown on the right.

Array
A pattern of objects made from one original. Arrays can be 1D, 2D, or 3D and either rectangular (laid out in straight lines) or polar (laid out in circles). In Blender arrays are initially instances of the original object and the Array modifier must be applied to edit any element individually. It’s important to remember when you do this that the split off meshes still keep the original object’s local origin location and this should generally be reset with Object-Transform-Origin to Geometry.

Banding
The 8-bit part of the image at the left is attempting to show the smooth gradient on the right, but without sufficient colors it can only show them as bands of flat color. You’ll notice that each band appears to be a gradient in itself; in fact if you cover up the surrounding colors you’ll see it is in fact solid. This optical illusion is called Mach banding.

The central image shows how the same range of colors can more convincingly show a gradient by being scattered (“dithered”) at different densities across the image.

Bezier
Pronounced bay-zee-eh, this is the last name of a French mathematician who discovered a family of geometric curves that allow users to adjust short sections of the curves without affecting the rest. This is of enormous importance in the graphic design and digital modeling industries and is the foundation of NURBS (non-uniform rational B-spline) modeling. Bezier interpolation is the classic easy-in-easy-out principle of 2D animation.

Blend mode, or Blending Mode
Blend modes are common throughout graphic design software wherever layers are used. The most
common blend mode ("Normal") is that the opaque areas of the selected layer obscure all the layers below. However the properties of the selected layer can also be used to darken, lighten, enhance the contrast of, or do other things to those below. For more information, there is an excellent article about blend modes at [http://photoblogstop.com/photoshop/photoshop-blend-modes-explained](http://photoblogstop.com/photoshop/photoshop-blend-modes-explained).

**Boolean operations**

There are four main Boolean operations in 3D modeling: Union (addition), Intersection, Difference A-B (subtraction), and Difference B-A (subtraction). For the first two the order of selection is not important but for subtraction whether A or B is selected first matters; in other words the subtraction operation is not commutative (if you remember your math classes); that is, it matter which order you select the objects. Boolean operations are only reliable with solid models that have no holes in the surrounding surface and have face normals that consistently point outwards. The result of a Boolean operation can be animated in Blender but you have to remember to make the target mesh invisible to the camera or it will appear in the final animation. You may also want to apply an Edge Split modifier to the result to clean up the appearance of the edges.

**Bump map**

A bump map moves the vertices of the mesh according to the gray value of a mapped image. For this to happen there has to be geometry present and this requirement for a dense mesh is one reason bump maps have been largely discontinued in favor of normal maps, which work with low resolution geometry. Bump maps affect the outline of objects, however, which normal maps do not.

**Bit depth**

Another term for color depth - see Channel and Color Depth below.

**Channel**

Image formats are divided into channels, which are grayscale images used to define the intensity of each primary color. For RGB light emitting images these are red, green, and blue; for CMYK light absorbing images they are cyan, magenta, yellow, and black. Some formats can only hold three channels and are unsuitable for high quality printing for this reason, as the conversion to CMYK in the printer driver will introduce inaccuracies. Other formats, particularly the common JPG, can not add channels such as alpha (transparency) or Z (depth). Currently the best format for storing general color images information is PNG, and the abbreviation for a four channel PNG file with alpha is PNG RGBA.

Channels have an additional characteristic called color depth. This refers to the number of bits used to define the color or transparency of each bit in the channel. 8-bit RGB color needs 24 bits for each pixel; 8-bit RGBA needs 32. Wider range, more accurate color, uses 12 or 16 bits for each channel, but produces much larger files for the same pixel resolution.

**Chyron**

A graphic overlay on the lowest third of a television broadcast, sometimes known as a screen crawl or a lower third - [https://en.wikipedia.org/wiki/Lower_third](https://en.wikipedia.org/wiki/Lower_third).

**Codec**

Short for Compressor/Decompressor, this is a mathematical process which analyzes the frames in an animation or image sequence and uses several techniques to reduce the file size. The two most important are Spatial Compression and Temporal Compression. The first reduces the size of a selection of single frames by using techniques similar to that in JPG compression; the second reduces the size of an
animation file by removing data that is common to sequences of frames between that first set of frames.

**Color depth**
The number of bits (basic units of information) used to define the color of a single pixel in an RGB image. 1-bit color is simply black and white; 8-bit (which defines 256 colors) was a standard on early computers. Today the minimum is generally 24-bit, which allows for 256 shades each of red, green, and blue to create just under 17 million colors. 32-bit adds an extra alpha channel for 256 shades of transparency. When color depth is too low the image will display banding.

**Compression**
Data compression is widely used for images, sound, and video/animation. For images there is a division between lossless compression, in which the original image is perfectly recreated, and lossy compression, in which a certain amount of data is permanently lost during the compression/decompression process. A GIF image uses lossless compression, while a JPG image uses lossy compression.

For video/animation there is a further division between static compression and temporal compression. Static compression reduces the amount of data in individual frames (generally using the JPG technique). Temporal compression identifies parts of neighboring frame images that do not move between those frames and replaces them with one common element. Temporal compression is at its most effective when one element in a scene is moving against a fixed background; in other words the camera is stationary. Static compression is most effective when there are large areas of flat color in a scene, such as evenly lit blocks of color like walls and furniture; some styles of animation that use flat color can also be well compressed using this technology.

**Cycles**
The physically based rendering engine included in Blender.

**Dielectric**
Contemporary physically based rendering (PBR) systems divide materials into dielectrics and metals. Each affects reflected and refracted light a different way. Dielectric materials are insulators, such as glass, paint, or plastic. They do not tint their reflections, and refract a fraction of the light they receive depending on their transparency. Metals, on the other hand, also reflect light but will tint it a color depending on the metal’s characteristics. However, all the refracted light is absorbed. Note that materials are only dielectric or metal; there is no partial option. Blender will include metalness in Cycles from v 2.79.

**Diffuse color**
The appearance of an object without reflection or glossiness. Another word for the glossiness component of an image is specular. Note that the simple diffuse/specular model for materials is outdated.
**Diffuse map**
The matt color of an object as defined by an image applied through a UV map.

**Dithering**
Mixing differently colored dots or pixels from a small selection of possible colors to simulate a color not in the available range. This is commonly done to expand the limited range of colors in formats such as GIF. Early computers used dithered patterns of black and white pixels to create shades of gray.

**Edge**
In 3D modeling and animation, a line between two vertices. Edges are vectors; in other words there is a direction associated with the edge as it moves from one vertex to the next. This is sometimes indicated with arrowheads drawn on the edge.

**Edgeloop**
A series of edges that go fully or partly around a polygonal model. The placement and continuity of edgeloops is particularly important for 3D models that will be animated and is called the model's topology.

**Face**
A surface made up of three or more edges, though edges can exist without a face being defined between them (a hole). All three edges must flow in the same direction around a face for it to be properly defined and the direction of this flow determines the direction of the face normal.

**Falloff**
The way in which an operation such as selection reduces in value the further vertices are from the center of the selection tool. Falloff can also refer to the soft edged nature of a digital paintbrush.

**Frame**
A single image in an animation or video. Common FPS (frames per second) rates are 24, 25, and 30. The illusion of animation from still images (known as persistence of vision) starts around the 12 FPS point, though the precise value depends on the individual and the images.

**Fresnel**
Pronounced “fren-el” as the S is silent, this is an effect named after Augustin-Jean Fresnel, an early nineteenth century French physicist best known for the flat Fresnel lens. Fresnel effects in computer
rendering, however, refer to the increasing reflectivity of a surface the more acutely you view it. Normal to a metal plate, for example, there may be very little reflection, but if you look at a glancing angle along its surface the reflected image is now sharp and brightly colored. For a transparent material such as glass the material is more transparent the closer to normal one views it so that the edges are mirror like while the center is clear.

**Frame animation**
A simple animation technology that uses individually drawn frames. This includes traditional drawn animation as well as Photoshop’s frame animation option. The animator must use their skill and experience to create smooth transitions across frames.

**GIF**
An old web image format (dating from 1987) that is undergoing a revival due to its versatility, ability to include transparency, animation capability, and lossless compression. Photoshop's frame based animation feature can be exported as GIFs. The acronym stands for Graphic Interchange Format, commonly pronounced with a hard G as “Giff”.

**Glow map**
A grayscale image that defines the areas of a UV map that will appear to glow when rendered.

**GLSL**
An abbreviation for the OpenGL Shading Language. Similar to C/C++, this allows shaders (materials) to be programmed for execution on the GPU, making for fast render times.

**Grayscale image**
An image limited to shades of gray. These shades can include 100% white and 100% black. A channel in an RGB or CMYK color image is a grayscale image defined as one of the component colors.

**Hard body model**
A model that will be either static or animated in rigid sections, such as a car with wheels. No distortion of the meshes is involved in the animation.

**Index of Refraction**
Known in Blender as IOR in the Transparency panel of the Materials tab in Properties, this property of a transparent object refers to the amount light is bent on entering that material at anything other than a normal (90 degree) angle. The speed of light is not constant, but slows when traveling through anything other than a complete vacuum. There is a list of indices of refraction at [http://en.wikipedia.org/wiki/List_of_refractive_indices](http://en.wikipedia.org/wiki/List_of_refractive_indices). Note that like vertex/vertices, the plural of index is indices.

**Ink and Paint**
A term used to define a type of hand drawn frame animation. Paint is used to create backgrounds, with gradients and shading. Ink, with its flat color character, is used to create the animated characters and objects in front of the background. In traditional Hollywood animation studios an inked outline was created by lead animators which was then filled in by less skilled individuals. The use of common ink colors meant that each frame looked identical, apart from movement, to the others. Because inked outlines were painted on the back of the transparent celluloid sheets (known as cels) the later solid color fills
could be slightly inaccurate without that being seen from the front.

**Instance**
A live linked, identical copy of an object. Changing any property of one instance in a scene will change all other instances of that object the same way; this is useful if you have twenty chairs in a room, for example, and want to make each slightly taller and a different color. Not every animation program supports instances, however. Photoshop and Blender do, the former by using Smart Objects and the latter by sharing meshes between objects.

Because instances refer to the same object data they need little more information than the original; a thousand instanced trees in a 3D modeled forest, for example, will result in a far smaller and more editable file than a thousand individual tree elements. These instances can be distributed randomly over a landscape using a particle system.

**Interpolation**
The mathematical estimation of the values between two specified values. The default interpolation method for many animation programs is Bezier (start slow, speed up, slow down); others are Linear (same speed between set values) and Constant (an instant jump from the previous keyframe value to the next). Computer generated interpolation replaces human “inbetweeners” in animation, and allows one person, or a small group, to make animations previously only possible for large studios.

**Keyframe**
A frame in an animation where at least one property of at least one object in the scene is precisely defined. The name comes from traditional 2D drawn animation, where the key frames of a scene were drawn by the master animator and the in-betweens drawn by less skilled artists called inbetweeners. The process of interpolating keyframes became known as tweening.

**Kiting**
The technique of using a kite-shaped quad face to combine two rows of faces into one. This is poor topology for a figure model that is going to be animated, but good practice for a hard body model such as a vehicle or machine in order to reduce the face count. An example of kiting is shown left.

**Layer**
As the name suggests, a layer is a group of graphic items that can not only be shown or hidden, but can appear above or below other layers. In 2D software such as Photoshop and Illustrator layers can be thought of as sheets of transparent plastic laid one on top of the other. Each sheet can contain images and text, and can be more or less transparent. Any layer can also affect the appearance of layers below in other ways, by blurring them for example. Layers can also be switched on and off, and reordered. In 3D software such as Blender, by contrast, layers are used only to group scene elements. Objects in layer 1 do not block out objects in layer 2, but either or both can be hidden or shown independently.

**Local coordinates**
In 3D modeling, the XYZ coordinates that are specific to an object, and that change when that object is moved or rotated.
Local view
Not to be confused with local coordinates, the local view of an object or objects hides everything else in the scene, even when rendering. Local/global view is toggled with the slash key on the keypad and if activated unintentionally is a common cause of confusion to those new to Blender.

Manifold surface
A surface in which every edge is next to two faces. In other words there are no holes in the surface. A manifold surface completely encloses a volume and can therefore be used for Boolean operations, structural analysis, and 3D printing.

Mask
The process of defining part of an image or video sequence as transparent by using the light and dark areas of a second image (the mask). A mask performs the same function as an alpha channel but may not be saved as part of the image file.

Mesh
A generic term for a polygonal surface that can be open or closed. A closed mesh defines a volume and can have solid properties such as density and elasticity.

Metalness
See Dielectric

Modifier
A non-destructive operation in Blender that allows animatable and reversible changes to an object. The order in which modifiers are applied to an object (known as the stack) can make a large difference in the result. Confusingly, the word “apply” also refers to making a modifier’s changes permanent.

N-gon (or Ngon)
A face with more than four edges. Blender has no limit to the number of edges in an N-gon, though generally the fewer edges there are around a face the better. N-gons are not acceptable in models for game design or in professional grade models for animation.

Node
See pole. The word also refers to the rectangular transformation features in Blender’s Node Editor.

Normal
The direction at ninety degrees to a surface. Normals are vectors, and point in one direction; often problems with rendering a model can be traced to inconsistent normal directions on neighboring faces. When several vertices are coincident (ie, at the corners of adjacent faces) they can be rendered with normals parallel to the faces they are part of (in this case the model looks faceted) or with an average value of all the vertex normals at that point (the model looks smoothly shaded). The actual geometry in both cases is the same. If the vertices of a face are running counter clockwise, then the normal is upwards.

Normal map
Frequently used in game graphics, a normal map is an efficient way to simulate a high resolution model by adjusting the way that light is reflected and shadowed on a low resolution model based on a 2D im-
Arriving light rays are rotated in three axes relative to the face normal by referring to the three color channels (red for local X; green for local Y; blue for local Z) of the colored normal map. The building of a normal map requires a high resolution 3D model, a corresponding low resolution 3D model, and building a map based on the differences between their geometry.

**NPR**
Non-photorealistic rendering. This includes stylized and cartoon style rendering

**NURBS model**
The name stands for Non-Rational Uniform B-Spline and refers to the surface edges of the model being defined by 3D equations that accurately define a 3D curved surface between them. A typical NURBS model is made up of many surfaces that flow into each other with defined continuity (position, tangency, or curvature) and is commonly used in the engineering/design community to develop shapes that can be manufactured to any degree of precision required. The math is somewhat similar to subdivision surfaces, but in a subdiv surface control is through the cage polygon, whereas with NURBS surface the cage is generally invisible and control is done directly on the surface. Blender has some NURBS capability but a specialist program such as Rhinoceros or SolidWorks is preferable.

**Origin**
The point in 3D model space where the XYZ coordinates are (0, 0, 0). The word is also used for the pivot point of a mesh. An object’s local origin may be at its geometric center for a simple form like a cube or sphere, or at any other point inside or outside the mesh’s boundary. Object origins move with the mesh in Object mode in Blender, but are fixed in Edit mode.

**Orthogonal**
A straight-on view or direction, from the Greek ortho (correct) and -gon (angle) without perspective distortion. Orthogonal directions are generally referred to as right, left, side, front, back, top, or bottom. Engineers and architects also refer to them as elevation and plan views.

**Orthographic**
A view or rendering that does not have any distortion due to perspective (from a camera lens, say). These are generally orthogonal views (see Orthogonal) but not always. Exploded engineering drawings are often made in oblique orthographic view. The advantage of orthographic views is that lengths and often angles are undistorted by distance and can be measured or accurately compared. Orthographic comes from the Greek roots ortho (correct) and -graphic (image).

**Parametric modeling**
This is the ability to define a feature (say, the radius of an edge fillet) by dimension so that, for example, all quarter inch fillets on an object can be changed to half inch instantly. Blender is not a parametric modeler, though some modifiers perform a similar function. Parametrics are typically a feature of engineering type NURBS modelers such as SolidWorks and Pro Engineer. Rhinoceros can incorporate parametric features with the Grasshopper plug-in.
**Particle system**
A means of distributing objects in space and time. Particle systems are valuable both for static models (randomly distributing rocks and trees in a scene, for example) and in animation (simulating sparks and explosions). They can also be used to create flocks of birds, crowds, and fluid simulations.

**PBR**
Short for Physically Based Rendering, a means of computing light interaction with surfaces that is based on real world physics. PBR is generally slower than non-physically based rendering methods but gives results that cannot be distinguished from photographs. See Dielectric.

**Pivot point**
The point, usually at the geometric center of an object, where operations such as rotation and scaling are centered. When Blender is in Edit mode the pivot point stays in place as the vertices are moved and this is one way to change its relative position. The pivot point of an object can also be redefined as the location of the 3D cursor, and for groups of objects the geometric center of the group. In other 3D software the pivot point is sometimes known as the local origin.

**PNG**
A widely used and convenient image format; the name stands for Portable Network Graphic, often pronounced “ping”. As the name suggests, this was developed for Web graphics and has largely replaced the older GIF and JPG formats. Standard PNG files cannot include animation like GIF but do include an alpha (transparency) channel. This alpha channel can be 8 or 24-bit. They are currently the most versatile way to save animation frames for editing and post processing.

**Pole**
A vertex where more or less than four edges meet, sometimes also known as a node or star point. Poles in other than relatively flat areas of a mesh create rendering problems, so their reduction to a minimum and location in flat, immobile, or hidden areas of the mesh is part of good topology.

**Polygonal model**
A computer model built up from flat faces (typically three or four sided). If the 3D shape defined by these polygons makes up a watertight shell (ie, has no holes) it is said to be a manifold surface and can define a solid object with volume, weight, center of gravity, etc. To be rendered properly the normals of the faces must all face outwards. Polygonal models can not be used to define accurate curved models, though they are widely used for 3D printing low resolution prototypes in plastics and metals. Poly models are easy to build, render, and animate.

**Post processing**
Whatever is done to an animation or image sequence after it has been rendered. Common post processing operations include depth of field, cartoon shading, color correction, and environmental effects such as rain and lighting glare.

**Posterizing**
See Banding.

**Proxy**
A low resolution model used in animation development. A proxy figure will share the same rig as the final
high resolution model and will replace it until the final rendering process. Using proxies saves memory and makes animating faster. A simple way to make a proxy in Blender is to use a low count subdivision model in the preview and a high count subdivision in the render.

**Quad**
An abbreviation for quadrilateral, or a four sided face. A well built model that is made from quads has continuous edges that follow the contours of its surface and will provide good topology for animation and UV mapping.

**Ray tracing**
A technique for generating an image by tracing the path of light from the pixels of the image plane (camera) and simulating its interaction with the scene objects in its path. This is the reverse of reality, where light comes from a source and interacts with objects before encountering the camera. Ray tracing produces high quality images that can simulate many optical effects such as reflection, refraction, and caustics. It is slower than raytracing, so ray traced materials and shadows should be kept to a minimum.

**Refraction**
The ability of a fully or partly transparent object to distort light rays traveling through it by slowing them down. Refraction is the basis of lenses and prisms, and can be accurately simulated in Blender by using the IOR (Index of Refraction) control element in the Material tab.

**Rendering**
The process of turning a 3D digital model, with its associated textures, lighting, and a virtual camera, into a 2D image. Images can be photo realistic, cartoon style, hand sketch style, or any combination of these depending on the computational processes used to combine the lighting with the geometry and the image textures.

**Rendering engine**
A rendering engine can refer to software that renders HTML script into readable pages, but in computer modeling/animation contexts means the software that converts the data in a 3D digital scene into a 2D image. Rendering engines can be internal (included in the modeling software) or external (a separate piece of software). Blender has two rendering engines: the default renderer and Cycles. Examples of external rendering engines include VRay, Brazil, Keyshot, and Octane. Experts can often tell which renderer a particular image was made as they all have slightly different characteristics.

**Resolution**
The term used to define the number of pixels along the X (width) and Y (height) axes in an image or video/animation. This is a function of aspect ratio, the ratio of X to Y. Old style television was 4:3, current high definition (HD) is 16:9, but there are many others, often associated with a particular video or film format.

**Rigging**
The process of creating the controls for an armature that in turn controls a mesh. This not only includes creating the bones that make up the armature, but also defining each bone’s influence on surrounding vertices, limits to the bones’ rotation and movement, the way that one bones controls the next, and the amount of flexibility in the bone itself. A finished rig is entirely composed of graphic elements; the original bones and armature will be hidden. To avoid inaccurate creasing around joints, the angle between two bones may also control a shapekey that adjusts the mesh separately.
**Safe area**
This is a leftover from the days of cathode ray tube (CRT) monitors and televisions, but one still sees references to it. In the time of analog broadcasting and CRT computer monitors, not all the image appeared on the screen. Some was lost, but exactly how much depended on the particular monitor or TV. So to make sure that important elements in animations or video (safe areas didn’t apply to cinema presentations) weren’t lost, the concept of Action Safe and Title Safe were developed. Action Safe areas are defined as 90% of the full screen width and height; Title Safe are 80%, as it is more critical that all of a title is seen. If you look at old television programs on YouTube you often see the boom microphone appearing on the top or side of the screen; these flubs were passed for broadcast as it was never thought they could be seen on the CRT screens of that era.

**Scanline rendering**
A method of rendering an image of a 3D scene that operates line by line, working down the image, to determine what is nearest the camera. Scanline rendering is efficient for small scenes but does not compare well to other methods as the complexity of the scene increases. Blender’s default renderer is a mixed scanline/ray trace system.

**Shader**
A shader combines the material, texture, lighting, and shadow information at a pixel in the rendered image to create a final result that may appear shiny, matte, cartoon shaded, photorealistic, or translucent. Shaders have a major impact on how objects look after rendering.

**Shape key**
An animatable change in a 3D mesh defined by moving vertices relative to a start arrangement called the basis. Shapekeys allow subtle changes of expression for character emotion and speech.

**Soft body model**
A mesh that will deform when animated, either with a rig or with shape keys. The predictable distortion and rendering of soft body models is a function of its topology: the way that edgeloops flow around the model.

**Specular**
The shiny quality of a surface as shown by highlights on an object. Specular lighting can be rendered separately for maximum control in post processing, and precisely defined on a 3D surface by using a grayscale specular map based on the UV map for that object.

**Spline**
A mathematically defined curve that can be controlled by handles and is often used in animation to define the shape of an object or the path that it will follow. This is often referred to as a Bezier (pronounced bay-zee-eh) curve after the mathematician who developed the concept.

**Stage right and Stage left**
Stage directions refer to the point of view of the actors, not the audience. Stage right is the left side of the stage as the audience sees it. In the same way, we name the arms and legs of a character as right or left from the character’s point of view, not as we see it when facing its front.
**Subdivision**
The mathematical process by which a low resolution, generally face extruded, model is smoothed to appear organic while retaining the simplicity and editability of the basic block model. Subdivided models are not suitable for some mesh based operations such as sculpting in Blender and have to be applied (turned into basic faces) for these processes to work.

**Subsurface scattering (SSS)**
The property of materials like wax, milk, and skin to scatter transmitted and absorbed light. This is important to give realism to features like characters’ ears.

**Timeline**
A horizontal window, generally placed at the bottom of the screen in a horizontal format, that shows scene animation on a time axis. Keyframes appear as diamonds or dots. A timeline animation uses keyframes with interpolation to control aspects of change in the scene, and only became possible with the use of computers in the animation process to replace human “inbetweeners” in animation studios.

**Topology**
The way in which an arrangement of edges and faces in a polygonal model define a form. Good topology reduces the chance of that model having rendering problems and increases the ease and predictability by which it can be animated with an armature. For human figures, good edgeloop topology generally follows and crosses the lines of the muscle groups. As many faces are possible are quads (four sided) and as few vertices as possible have less or more than four edges meeting at them. Particularly in the computer game industry, good topology also uses as little geometry as possible. Two ways to increase apparent detail include normal and specular mapping.

**Translate**
The correct term for moving an item from one location to another. Translation in Blender is started with the G key.

**Transform**
The term for any operation that does not change the relative location of subobject items to each other. Transforms in a 3D program include translation (see above), rotation, and scaling. Rotation and scaling take place around a pivot point, which must be defined before the operation. Scaling can be along one, two, or all three axes; the last is known as uniform scaling.

**Tri**
An abbreviation for a triangular face. Tris have three vertices and three edges, and are always planar. They are the simplest computational way to represent solid 3D forms. Models for games should always be built in tris, whereas models for animation should use quads.

**Tweening**
Short for “in-betweening”, this is the process of creating intermediate drawings between keyframes. For hand drawn animations this is generally undertaken by secondary animators, leaving the lead animators free to define the “key” frames throughout a scene. In computer animation this work is done by the software, which uses a variety of mathematical methods, defined by the animator, to do the work of a tweening crew.
**Unwrapping**
The process of slicing and adjusting the shape of a 3D surface to best display a 2D image that will be shown on it.

**UV map**
A 2D graphic that defines how a flat graphic will be shown on a 3D object. UV mapping can be defined by the modeling software or carefully defined point by point. A good UV map can replace high resolution modeling for interactive game animation as it can instantly adjust shininess, glow, reflections, and shading as if they came from a much higher resolution (and slower) 3D model.

**Vertex**
A point in 3D space defined by XYZ coordinates (note that the plural of vertex is vertices). Vertices differ from simple points by having a normal direction (which is parallel to that of the face they are part of) and a color. Vertices exist independently of edges and can be extruded to create them.

**Vertex group**
A selection of vertices in a mesh. Vertex groups can be used for many purposes, including pinning a cloth to a surface, assigning materials, and distributing objects across a surface. Weight painting creates a vertex group with smoothly distributed values. Directly selecting vertices generally means every vertex has a value of either 0 (unselected) or 1 (selected).

**W**
When a 3D model is UV unwrapped the horizontal direction in the flat map on the screen is the U and the vertical is the V. In some cases (generally normal mapping) you need to define a strength facing inwards and outwards. This direction is defined as W, and as with the Z direction in world and local space, represented as shades of blue.

**Weight painting**
The process of assigning a value (generally between 0 and 1) to each vertex in a mesh. Weight painting is done with a brush that has a strength, size, and falloff curve. Weight painting is useful in distributing elements across a mesh, such as trees in a landscape or hair on a head.

**Wireframe**
A display mode where only the edges of a mesh are shown. This often makes it easier to select elements of the mesh such as vertices and edges, though at the cost of some visual ambiguity between front and back of the object. Blender has a hybrid shaded/wireframe style available in Edit mode. Wireframe was the earliest type of computer generated form representation.

**World coordinates**
The constant XYZ axes in a 3D view. In Blender these are indicated by the tripod in the lower left of the 3D window. The axes shown on an object in the scene can be defined as World or Local.

**X-sheet**
Known as the Dope Sheet in Blender, this was traditionally a record of all the frames in a hand drawn animation with their transitions and associated sound. In Blender the Dope Sheet is sometimes referred to as “the Timeline on steroids” and is the most convenient way to adjust timing in an animated scene. One
or more key frames can be moved, scaled, deleted, or duplicated.

**XYZ**

This refers to the three orthogonal (mutually perpendicular) directions of three-dimensional space. In Blender the screen in Front view represents an XZ view, but some programs define it as XY. The three additive primary colors Red-Green-Blue are always used to represent the XYZ axes.

**Z buffer or Z channel**

Sometimes known as the Z buffer, this refers to the local Z axis of a camera, and is a channel of information in an image format that stores the distance of each rendered pixel from the camera plane. Z channel information is most often used to control depth of field (focusing) on particular elements in the scene. It can also be used to define mist.

**Z fighting**

The characteristic pattern in a render when two surfaces occupy the same location and the rendering engine cannot decide which to place on top of the other.

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