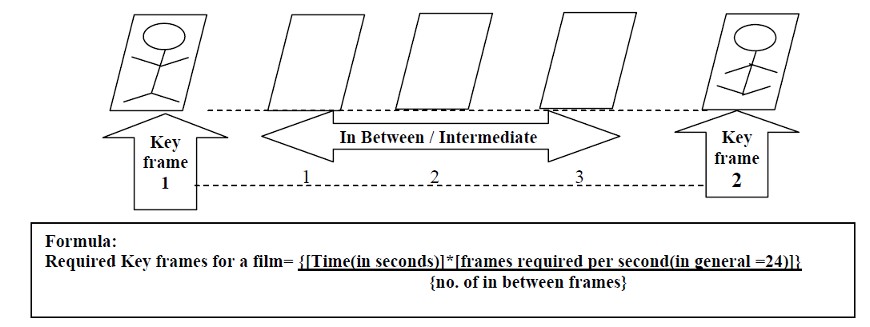
The word Animation is derived from ‘animate’ which literally means ‘to give life to’, ‘Animating’ a thing means to impart movement to something which can’t move on its own.



In order to animate something, the animator should be able to specify, either directly or indirectly, how the ‘thing’ is to move   
through time and space. We have already discussed various transformations in Block 2 Unit 1 using which you can impart   
motion, size alteration, rotation, etc, to a given graphic object. Before dealing with complexities of animation, let us have a   
look at some basic concepts of Animation in section 1.2. In section 1.3, we will discuss different kinds of animations.   
In our childhood, we all have seen the flip book of cricketers which came free along with some soft drink, where several   
pictures of the same person in different batting or bowling actions are intact sequentially on separate pages, such that when we   
flip the pages of the book the picture appears to be in motion, this was a flipbook (several papers of the same size with an   
individual drawing on each paper so the viewer could flip through them). It is a simple application of the basic principle of   
Physics called Persistence of Vision. This low tech animation was quite popular in the 1800s when the Persistence of vision   
(which is 1/16 th of a second) was discovered. This discovery led to some more interesting low tech animation devices like, the   
zoetrope, wheel of life, etc. Later, depending on many basic mathematics and physics principles, several researches were   
conducted which allowed us to generate 2D/3D animations.

Sequencing of Animation Design

Till now we have discussed a lot about the traditional and current trends of computer generated animation but now it, is time to practically discuss the necessary sequencing of animation steps which works behind the scenes of any animation.   
This sequencing is a standard approach for animated cartoons and can be applied to other animation applications as well.   
General Steps of designing the animation sequence are as follows:

1) Layout of Storyboard: Storyboard layout is the action outline used to define the motion sequence as a set of basic

events that are to take place. It is the type of animation to be produced which decides the storyboard layout. Thus, the storyboard consists of a set of rough sketches or a list of basic ideas for the motion.

2) Definition of Object: The object definition is given for each participant object in action. The objects can be defined

in terms of basic shapes, associated movements or movement along with shapes.

3) Specification of Key Frame: It is the detailed drawing of the scene at a certain time in the animation sequence.

Within each key frame, each object is positioned according to time for that frame. Some key frames are chosen at the extreme positions in the action; others are spaced so that the time interval between key frames is not too great. More key frames are specified for intricate motion than for simple, slowly varying motions.

4) In-between frames Generation: In-between frames are the intermediate frames between the key frames. The number

of in between frames is dependent on the media to be used to display the animation. In general, film requires 24 frames per second, and graphic terminals are refreshed at the rate of 30 to 60 frames per second. Typically the time interval for the motion are set up so that there are 3 to 5 in-betweens for each pair of key frames. Depending upon the speed   
specified for the motion, some key frames can be duplicated.

Note: There are many applications that do not follow this sequence like, real time computer animations produced by vehicle driving or flight simulators, for instance, display motion sequence in response to setting on vehicle or aircraft controls, plus the visualization applications are generated by the solution of numerical models. And for frame-by-  
frame animation each frame of the scene is separately generated and stored. Later the frames can be recorded on film or they can be consecutively displayed in “real time playback” mode.

In order to explain the overall process of animation mathematically consider the Figure 2. In order to have smooth

continuity in motion of objects, a number of in-between frames are sandwiched between two key frames Now, there is   
a relation between different parameters, i.e., key frame, in-between frame, time, number of frames required per second   
which is

Example 1: How many key frames does a one-minute animation film sequence with no duplications require ? Solution: One minute = 60 seconds

No. of frames required per second=24

No. of frames required in entire film=24\*60=1440

That is we would need 1440 frames for a one-minute animation film.

Example 2: How many key frames does a one-minute animation film sequence with no duplications require if there are five in   
 betweens for each pair of key frames ?

Solution: One minute = 60 seconds

No. of frames required per second = 24 No. of in-between frames = 5

No. of frames required in entire film=(24\*60)/5=288

That is we would need 288 key frames for a one-minute animation film if the number of in-between frames is 5.

Video animation frames

It can be measure by the following formula:

Video size = Width x Height x color depth x FPS(frame per second) x runtime in seconds.

(How big is each page x how rich color it contains x how many pages per second x how long ) Since BPS (bit per second ) is the amount of info per second, Video size can be measured by: Video size = BPS x total runtime in seconds

For example, a video of duration (T) of 1 hour (3600sec), a frame size of 640x480 (WxH) at a color depth of 24bits and a frame rate of 25fps.

The pixels per frame = 640 \* 480 = 307,200

Bits per frame = 307,200 \* 24 = 7,372,800 = 7.37Mbits Bit rate (BR) = 7.37 \* 25 = 184.25Mbits/sec

Video size (VS) = 184Mbits/sec \* 3600sec = 662,400Mbits = 82,800Mbytes = 82.8Gbytes   
If this is a High Def video, the pixels per frame is 1920 x 1080 = 2,073,600 > almost 600 GB

Types of Animation Systems

We have discussed above that the sequencing of animation is useful in developing any animation. This sequencing is more or less the ‘same in all animation systems’. Before proceeding to the types of animation in the next section, let us study the types of Animation Systems.

So let us discuss a few animation systems, which are generally used:

Key Frame Systems

This technique is for low-level motion control. Actually these systems include languages which are designed simply to generate the in-betweens from the user-specified key frames.

Usually, each object in the scene is defined as a set of rigid bodies connected at the joints and with a limited number of degrees   
of freedom. Key frame systems were developed by classical animators such as Walt Disney. An expert animator would design   
(choreograph) an animation by drawing certain intermediate frames, called Key frames. Then other animators would draw the   
in-between frames.

The sequence of steps to produce a full animation would be as follows:

1) Develop a script or story for the animation.

2) Lay out a storyboard, that is a sequence of informal drawings that shows the form, structure, and story of the animation.

3) Record a soundtrack.

4) Produce a detailed layout of the action.

5) Correlate the layout with the soundtrack.

6) Create the "key frames" of the animation. The key frames are those where the entities to be animated are in positions such   
 that intermediate positions can be easily inferred.

7) Fill in the intermediate frames (called “in-betweening” or “tweening”).

8) Make a trial “film” called a “pencil test”.

9) Transfer the pencil test frames to sheets of acetate film, called “cels”. These may have multiple planes, e.g., a static   
 background with an animated foreground.

10) The cels are then assembled into a sequence and filmed.

With computers, the animator would specify the key frames and the computer would draw the in-between frames (“tweening”).   
Many different parameters can be interpolated but care must be taken in such interpolations if the motion is to look “real”. For   
example, in the rotation of a line, the angle should be interpolated rather than the 2D position of the line endpoint. The simplest   
type of interpolation is linear, i.e., the computer interpolates points along a straight line. A better method is to use cubic splines   
for interpolation (which we have studied in Block 3). Here, the animator can interactively construct the spline and then view   
the animation.

Note: From the above discussion, it is clear that in key frame systems the in-between frames can be generated from the

specification of two or more key frames, and among them we can set the motion path of the object under consideration by

describing its kinematics description as a set of spline curves. For complex scenes we can separate the frames into individual   
components or objects called cels (Celluloid transparencies). In these complex scenes, we can interpolate the position of   
individual objects between any two times. And in this interval the complex objects in the scene may suffer from various   
transformations like the shape or size of object may change over time, etc., or the entire object may change to some other   
object. These transformations in a key frame system lead to Morphing, Zooming, Partial motion, Panning (i.e., shifting of   
background/foreground to give the illusion that the camera seems to follow the moving object, so that the background/   
foreground seems to be in motion), etc.

MORPHING: Transformation of object shapes from one form to another is called morphing (short form of metamorphism). Morphing methods can be applied to any motion or transition involving a change in shape. To understand this, consider the

Scripting Systems are the earliest type of motion control systems. Scripting systems allow object specifications and animation   
sequence to be defined with a user input script., and from this script, a variety of various objects and motions can be   
constructed. So, to write the script the animator uses any of the scripting languages. Thus, the user must learn this language and   
the system. Some scripting systems are PAWN (An embedded scripting language formerly called Small) with syntax similar to   
C, ASAS (Actor Script Animation Language), which has a syntax similar to LISP. ASAS introduced the concept of an actor,   
i.e., a complex object which has its own animation rules. For example, in animating a bicycle, the wheels will rotate in their   
own coordinate system and the animator doesn't have to worry about this detail. Actors can communicate with other actors by   
sending messages and so can synchronize their movements. This is similar to the behavior of objects in object-oriented   
languages.

Parameterised Systems these are the systems that allow objects motion characteristics to be specified as part of the object definitions. The adjustable parameters control such objects characteristics as degree of freedom, motion   
limitations, and allowable shape changes

TYPES OF ANIMATIONS

Procedural Animation: This type of animation is used to generate real time animation, which allows a more diverse series of actions to happen. These actions be created using some could otherwise predefined animation procedures are used to define movement over time. There might be procedures that use the laws of physics (Physical i.e., modeling based) or animator-  
generated methods. Some example of procedural animation is collision which is an activity that is the result of some other action (this is called a “secondary action”), for example throwing a ball which hits another object and causes the second object to move; simulating particle systems (smokes water etc.) hair and for dynamics. In computer video games it is often used for simple things like players head rotation to look around, etc.

Representational Animation: This technique allows an object to change its shape during the animation. There are three sub-  
categories to this. The first is the animation of articulated objects, i.e., complex objects composed of connected rigid segments.   
The second is soft object animation used for deforming and animating the deformation of objects, e.g., skin over a body or   
facial muscles. The third is morphing which is the changing of one shape into another quite different shape. This can be done   
in two or three dimensions.

Stochastic animation: This uses stochastic processes (A stochastic process can be considered as a random function). This randomness could be in time or space variable of function, the randomness in time leads to stochastic animation to control groups of objects, such as in particle systems. Examples are fireworks, fire, waterfalls, etc., or speech audio signal, medical data ECG, BP, etc, or Random walk.

Behavioural animation: Used to control the motion of many objects automatically. Objects or “actors” are given rules about   
how they react to their environment. The primary difference is in the objects being animated, instead of simply procedurally   
controlling the position of tiny objects. This type of animation is generally used to animate flocks, school, herds and crowds.   
Examples are schools of fish or flocks of birds where each individual behaves according to a set of rules defined by the   
animator.

So as to generate these types of animations, we need to have familiarisation with some general functions which every

animation software is suppose to have. In general animation functions include a graphic editor, a key frame generator, an in-

between generator, and standard graphic routines. The graphic editor allows us to design and modify object shapes using

splines surfaces, Constructive Solid Geometry (CSG) methods and other representational schemes.

In the development of an animation sequence some steps are well suited for computer solutions, these include object

manipulations, rendering, camera motions and the generation of in-betweens. Animation packages such as wave front provide special functions for designing the animation and processing individual objects.

Some general functions available in animation packages are:

• Object Function to store and manage the object database, where the object shapes and associated parameters are stored and   
 updated in the database.

• Object Function for motion generation and object rendering. Motions can be generated according to specified constraints   
 using 2D and 3D transformations. Standard functions can then be applied to identify visible surfaces and apply the

rendering algorithms.

• Object function to simulate camera movements, standard motions like, zooming, panning, tilting etc. Finally the specification   
 for the key frames, the in-between frames can be automatically generated