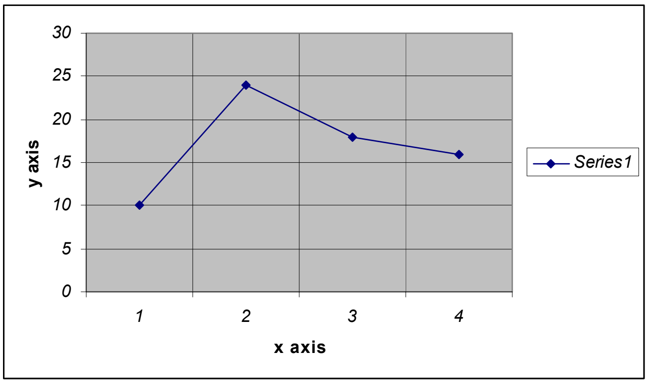
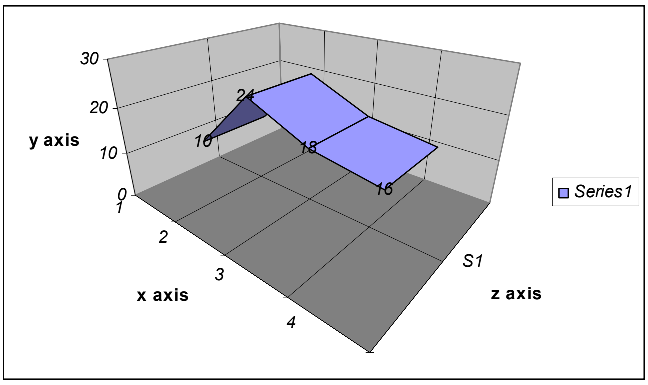
J242 Multimedia design

Week 2 - Modelling.

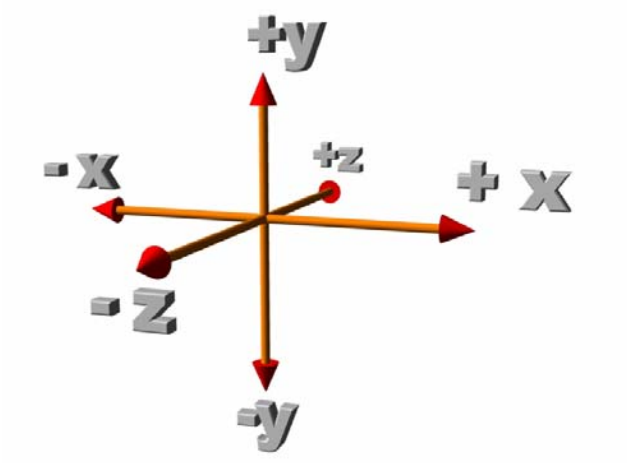
When you think about animation in 3D, by necessity you are also thinking about 3D objects in that space.
Imagine you pick out a point in front of yourself with the index finger of your left hand and say "We want our object right here.."
Now how do we define "right here.."
The method used by most computer graphics systems is very similar to the method most of us used in high school maths classes when we drew graphs.
Draw two lines perpendicular to each other and mark off little ticks at certain distances. This is a simple two dimensional system called a **coordinate system**. The numbers that identify where a point is placed within the graph are called coordinates. **The lines perpendicular to each other are called axis**, generally the x axis is the horizontal and the y axis is the vertical.



It's easy to extend this two dimensional system into 3 dimensions by the addition of another axis, generally called the **z axis, which gives us depth.**



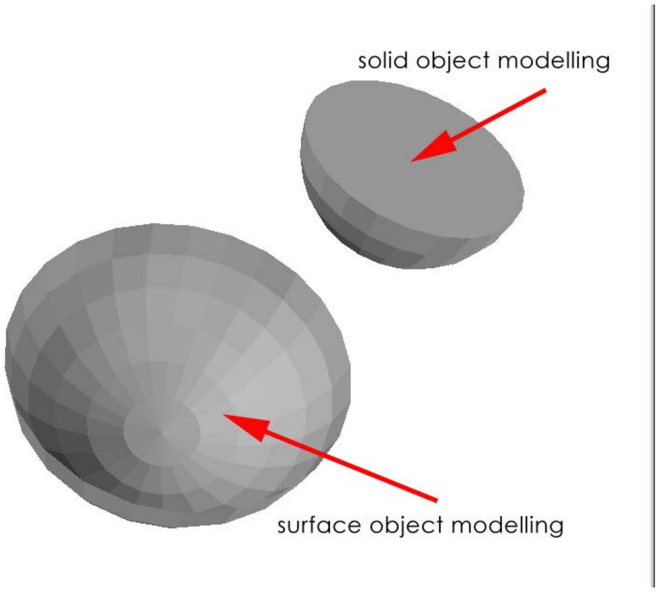
We use this system to accurately define the virtual space we inhabit when working in three dimensions. Whether working in two or three dimensions, whether we refer to its axis or planes, systems in which the coordinates are defined by mutually perpendicular axis are called **Cartesian coordinate systems**, after Rene Descartes who first devised them.
In modelling an object in 3D we use these coordinates to define our models. We define the object thoroughly enough so that a computer can display it on a screen from any of a number of views. In most systems we define the shape or form of our model in one of two fundamental ways. Solid or surface modelling.



Solid v surface object modelling.

If you held a brass sphere in your hand, it could be one of two things. Firstly it could be a solid brass ball. If we cut the ball in half, each half would be a solid shape with no hollow or empty space. In computer terms this is a solid model. Applications that deal with solid object modelling are mainly found in the worlds of engineering or science. Objects need to be able to accurately mimic materials with regard to inertia, density, mass, etc.
However if when you cut the ball in half you were left with two hollow thin surfaces with empty space inside you would be dealing with surface modelling. For the great majority of cases the data needed to accurately compute solid objects is not needed and we are able to harness our computing power to the computationally simpler surface modelling.

In this course we are concentrating on surface modelling but we will also examine other model types, such as particle systems and volumetric, useful for modelling things like fire, smoke & liquids that have a more ephemeral quality and are very hard to approximate with either solid or surface modelling.



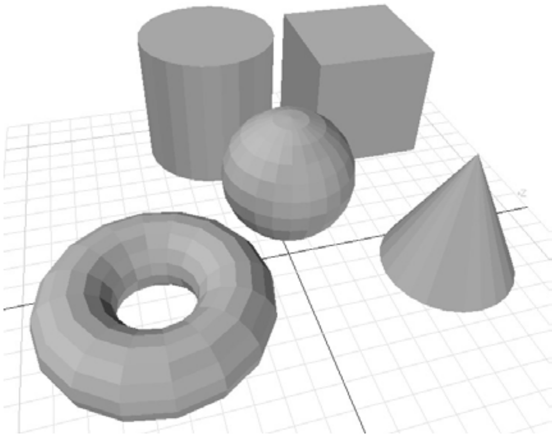
Object creation.

Computers are good at dealing with numbers and quantifiable entities, but aren't so good at subjective concepts. We can easily make something twice as long, or half as high, though it's harder to make something more "petal like". Because of this we use numerically quantifiable and manipulative concepts of shape. We call our objects geometry. This is also what mathematicians call the study of shapes.

Think back to our index finger pointing to a place in space. Lets call this a point. It has no size or body, it is just a location defined by our Cartesian system. Now move that point in exactly one direction. It becomes a line. It has one dimension, length. Move the line in the same way we moved the point, in one direction and you have a plane. It now has two dimensions, length and width. If you selected three points on this plane and connected them you would have a surface. Each point is called a **vertex**, plural **vertices**. We used a three pointed example but this surface, called a polygon, can have various numbers of vertices. *Polygon is Greek for many sided.*
We can also connect these polygons to each other, sharing vertices, at different angles, to create different surfaces. The type of modelling that defines surfaces as consisting of flat polygons is referred to as **polygonal modelling.**
Polygonal modelling is easy, and good for flat surfaces but curves, like tree branches and organic shapes, need to be approximated using large numbers of small polygons to approximate the curve. This line approximation is sometimes called **polyline** and suffers from a high point count and the curve is never truly smooth. It also can be hard to manipulate. The techniques used to reduce the normally high polygon counts are referred to as **culling**.

Primitives

Certain basic geometric shapes are so easily mathematically defined and so widely used in 3D graphics that software packages handle them separately as a set of special entities. These shapes are referred to as **geometric primitives**. They include familiar shapes such as cubes, spheres, cones and cylinders. These shapes are so useful because they are so common, and so common because they are so useful. A great many man made objects are composed of some combination of these shapes. A table for example could be constructed using a flat box as the tabletop and legs made of long tapered cylinders.


basic primitives

Boolean Operators

Basic primitives (and other shapes) can be constructed using another technique known as Boolean operations. Named after British mathematician and logician, George Boole, Boolean operations allow us to logically deal with combining content in 3 ways.

- **Addition**
  (Union) Joins two objects to form a third object.

- **Subtraction**
  (Difference) Takes away from an object the shape occupied from another object

- **Intersect**
  New object created from the shared (intersecting) space occupied by two objects.

Splines

Another method of modelling uses smooth curves instead of straight lines. Polyline uses linear approximation, which if viewed closely enough, never creates truly smooth curves. The curve itself is also very hard to manipulate because it is created with so many control points.
The method of creating simple curves is known as spline patching. The term spline comes from the wooden ship building era. Ship builders would bend planks by placing them between several fixed posts called '**ducks**", the placement of the ducks determined the amount of curvature of the plank. The finished, curved plank was called a **spline**.
In 3D modelling, the wooden plank is the curve, the points which control this curve are known as control points.
There are two fundamental types of spline curves.
Interpolating Spline, where the line goes thru all of the control points, and
Approximating Spline, where the line goes near, but not thru, the control points.
Of the two main types of spline curves the approximating type is most common.
Some types of approximating spline curves.

- B Spline
- Bezier Spline (using control handles)
- NURBS Spline (**N**on **U**niform **R**ational **B**-**S**pline)