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(Part II)

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(Chapter 1: A brief history, the current era, and looking ahead)

(Why learn 3D-modelling?)

The basic premise of such a club is to teach the basic skills of 3D modelling using internationally accepted industry-level 3D modeling software to provide students with the founding skills to help further their ability and understanding of computer aided design which is a requirement of many courses at university and additionally during engineering-related careers.

Such possible courses include:

(1) Architecture
(2) Mechanical Engineering
(3) Mechatronics Engineering
(4) Industrial Engineering
(5) Product Design
(6) Product Safety

Teaching students basic 3D-modeling skills will be able to provide a good base for such courses and will help develop such skills early to ensure that they may be able to become proficient users of such software and build the transferable skill of intuition of 3D modeling paradigms which may later be transferred to other software.

3D-modelling has many different applications:

(1) Computer-aided manufacturing in industry
(2) Artistic renderings in the video game or movie industry
(3) Architectural Models in the construction industry
(4) Simulations of forces and stress of products in product design

(A retrospective: Leading up to the innovation of 3D computer based design)

(1) After the beginning of the industrial revolution in the late 18th century a need for specialized drawings rose due the increased number of machinery being manufactured for various uses in the metal working, textiles, and later the electrical industry. This increased need lead to a specialized table being developed called the **drafting table** which allowed the user to easily make technical drawings that outline how a worker (or machinist) should manufacture said design. We call this a **technical drawing** or a **blueprint**. Figure 1.1 shows a drafting table with a blueprint on its drawing surface.

(2) As the world progressed and ever more products were being produced the need for designer grew too, by the beginning of the 19th century vast rooms full of designers would labor away producing technical drawings for various components and assemblies which would become part of a much

larger machine or product later. Figure 1.2 shows an image of one such drafting room.

(3) The first major boom of design innovation happened during the early-20th century in the form of the Second World War where countries were competing in arms-races that would determine the outcome of the war. Here new practices were developed which more closely resemble how research and design teams operate in the modern age to increase the productivity of an already stressed workforce. Some changes included: smaller design teams working on individual assemblies which later would be integrated together by a head engineer to produce the final end design such as an aircraft or ship; or how drafting was standardized to make sure that designers were able to read each other's drawings across borders and companies.

Here drafting rooms grew ever larger and this resulted in lower effectiveness due to the sheer number of workers present. Figure 1.3 shows a colorized image of one such design room.

(4) The next major design boom came in in the mid-20th century during the cold war where once again an arms-race resulted in nations competing to produce ever more complex designs to gain the upper hand in said cold war.

During this time, the space is taking place and has resulted in a plethora of new innovation and at this point design rooms had almost reached their breaking point. However, during this time the first **calculating computers** had been put into service reducing the number of hand calculations engineers would need to make before a design was finished greatly reducing the number of **human-calculators** and engineers required. Figure 1.4 shows Katherine Johnson, a calculator, at NACA and later NASA. Figure 1.5 shows one such model of a calculating computer.

(5) During this time the first **CAD** or **computer-aided-design** program was developed and was used by large engineering firms such as General motors, Lockheed, and IBM. Its name was sketchpad and whilst still extremely costly it proved to be an indispensable tool for designers and engineers. Figure 1.6 shows sketchpad in action.

(6) In the late 20th century computer had become powerful enough for teams to work solely on computer with great speed. During this time, 3D-modeling had become advanced enough to be used in theater where it was used in CGI effects and later for the first wholly animated movie: Toy Story in 1995. Figure 1.7 shows the 1995 release of "Toy story".

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(The modern 3D-design landscape)

As mentioned previously, we have identified the major uses of 3D-modelling today. Over the last 200 years design has come a long way and up until about 60 years ago 3D computer-based design was unheard of.

Today, an industry standard to 3D-modelling and design has been developed where the following programs take major prominence:

(1) Fusion 360 for mechanical and electrical design
(2) Maya for CGI effects, architectural design, and artistic ventures
(3) Cinema 4D for CGI effects, architectural design, and artistic ventures
(4) 3DS Max for CGI effects, architectural design, and artistic ventures
(5) Sketchup for rapid prototyping as it provides a more user friendly modelling environment
(6) Blender for its large versatility in being used for mechanical and electrical design, architectural and product renderings, artistic venture, and CGI effects.

The above mentioned software can be split into two distinct categories:

(1) Parametric
(2) Mesh-based (or direct)

Parametric based modeling is where mathematical functions are used to define how an object is manipulated through commands by the user, whereas **mesh-based** is where the user directly manipulates the vertices, faces, and edges of an object to their requirement. However, please remember this refers to how mesh is manipulated, not how it is represented in the computer as the graphical representation of a mesh is based on mathematical vector functions.

(Blender, Fusion 360, and the industry standard of design)

When designers and engineers are working in a 3D-modelling program they tend to use **keyboard shortcuts** to reduce the time spent clicking with their mouse to and for thus increasing their efficiency, however due to the vast number of programs developed over the years a problem arises: when a designer or engineer goes from one industry to another the software they use to conduct their work also changes thus meaning they have to relearn said keyboard shortcuts.

To solve this, the above programs use the industry standard of keyboard shortcuts which allows any user to switch between programs without a steep learning curve. Moreover, in the coming chapter we will learn about key 3D-modeling concepts that will help us learn modeling intuition thus allowing us to transfer our learning to any program. While our learning will focus on

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Blender for now, the skills you learn can be applied to almost any 3D-modelling program and the keyboard shortcuts to all industry standard programs.

We will later learn how to use Fusion 360, which although parametric (instead of mesh-based like blender) the 3D-modelling paradigms you learn in blender can be quite easily applied to Fusion 360 or other parametric based design software. Keyboard shortcuts remain relatively the same.

(The future)

In the future we may perhaps be able to create models using **VR** or **virtual reality** where a designer may be able to build an object as if they were building the object in real life instead of through a computer screen.

Moreover, as computers become able to process data more rapidly real-time renderings of ray-traced environments may be possible allowing designers, especially those in the architectural, product design, and movie / video game industry, to be able to create **photorealistic** environments in real time instead of waiting for a computer to process the individual light rays in such a scene.

(Further reading for Chapter 1)

(1) A history of engineering in color
https://www.bricsys.com/blog/the-history-of-engineering-in-color

(2) NASA computers
https://physicstoday.scitation.org/do/10.1063/pt.5.9084/full/

(3) Sketchpad
https://en.wikipedia.org/wiki/Sketchpad

(4) Pixar Renderman
https://en.wikipedia.org/wiki/Pixar_RenderMan

(5) Pixar Image Computer
https://en.wikipedia.org/wiki/Pixar_Image_Computer

(6) Ray-Tracing
https://developer.nvidia.com/discover/ray-tracing#:~:text=Ray%20tracing%20generates%20computer%20graphics,back%20to%20the%20light%20sources.

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(Chapter 2: Fundamental Paradigms in mesh-based 3D modeling)

(The three dimensions)

As in vector mathematics there are three main **dimensions**, the red arrow represents the **x-axis**, the green arrow the **y-axis**, and the blue arrow the **z-axis**. Whilst the mathematical notation has changed we still use three dimensions to create a 3D object. Figure 2.1 shows this.

Dimension	Vector Mathematics	3D software
X	Represented by “i”	Red arrow
Y	Represented by “j”	Green arrow
Z	Represented by “k”	Blue arrow

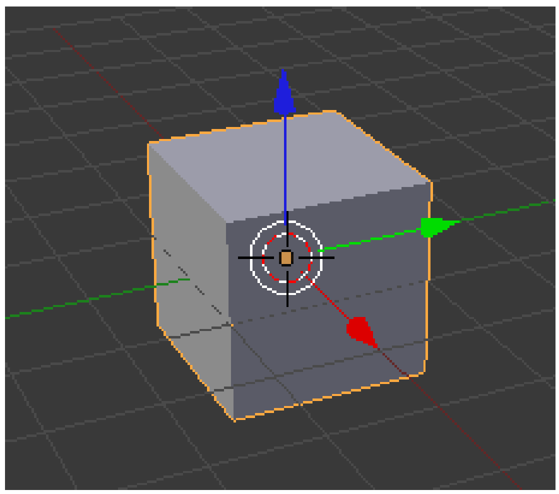

Figure 2.1 – A cube with three arrows represnting the three axis.

Using such axis we can manipulate our object in the three dimensions in the following ways:

(Object manipulation)

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