Volume

2

… Books must follow sciences and not sciences books…

[Francis Bacon, IProposition touching Amendment of Laws]

… Young men are fitter to invent than to judge, fitter for execution than for counsel, and fitter for new projects than for settled business…

[Francis Bacon, Of Youth and Age.]

CAD Issues

EXPLOITATIONS AND COMMUNICATIONS

CAD Issues

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General Index

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Paper drawings *vs* Digital drawings

.1. FOREWORDS:

The following text always refers to the artistic or architectonic field, as the latter is the main issue of CaribCAD, but the definitions can also be purged of very specific architectonic references and thus being of general value for every field related to graphical representations.

In the present text a *hand drawn drawing*, also defined as *paper-based* or *analogue drawing*, is not to be confused with a *paper drawing* being each and any *drawing* - also *plotted digital drawings* - that is *printed*, *draft* or *plotted* on paper.

.2. WHAT IS A HAND DRAWN DRAWING? [PAPER-BASED OR ANALOGUE DRAWING][1]

It is an analogue, symbolical, quoted, and scaled *representation* of an architectonic object and showing various aspects of it.

Bibliography:

[1] See Heribert Hutter, *Drawing: History and Technique* (tr. 1968); K. T. Parker, ed., *Old Master Drawings* (14 vol., 1940, repr. 1970); J. Meder and others, *The Mastery of Drawing* (2 vols. 1978).

1. Representation:

It is the depiction of building works, their parts or internal spaces (s. also SURVEY) through pictorial or graphical media or three-dimensional models.

Representation is done for the sake of:

1. theoretical reflection, (THEORY OF ARCHITECTURE),
2. further elaboration of the project by the architect/engineer (SKETCH, PERSPECTIVE, AXONOMETRIC DRAWING, ISOMETRY, PROJECTION, AND DEVELOPMENT),
3. discussion with the client or the works' direction (ARCHITECTONIC PROJECT, EXECUTIVE DRAWING, URBANISTIC PLAN).

While for the former two sakes it is not necessary a METRICAL SCALE, for the latter - the only allowed way to draw architectonic projects, executive drawings and urbanistic plans - it is to draw them in scale and according to a rapport indicated on the drawing itself.

At the present days, to build a new building in Europe, the following drawings are necessary: PLANIMETRY, in which the situation of the building is represented in relation to the surrounding buildings and to the site/land; PLANS, SECTIONS and FRONT ELEVATIONS.

Moreover all the detailing drawings for unusual element - respect to the normal building practice or through the use of which the architect is trying to express his/her own architectonic conceptions - must be represented.

The architectonic and/or urban model of a building is useful to the theory and history of architecture, to the understanding by the client and frequently to check some building developments.

Re-drawing the original was, till 1800 ca, the sole and exclusive way of reproducing graphic representations; later on, building projects for great dimensions works have been reproduced by lithography; since the last third of the last century, it is possible to dispose of the cyanotype (blueprint) system. (MISTAKES)

.1. Drawing:

Art of the draftsman. In its broadest sense it includes every use of the delineated line and is thus basic to the arts of painting, architecture, sculpture, calligraphy, and geometry, etc. The word drawing is commonly used to denote works in pen, pencil, crayon, chalk, charcoal, or similar media in which form rather than colour is emphasised. For centuries drawings have been made either as preparatory studies (e.g. cartoon) or as finished works. Preparatory drawings sometimes reveal a vigour and spontaneity lacking in the completed work. This, then, is resulting as easily it can be imagined in difficulties of understanding, representation and reproduction of those drawings. Processes such as *etching*, *engraving*, and *lithography* are often used to reproduce drawings.

.2. Survey:

1. The operations useful to REPRESENT an urbanistic or architectonic complex, an architectonic masterpiece or part of it (monuments' survey), for the sake of RESTORATION or to compile a list of all the monuments subjected to protection bonds. **2**. The operations useful to draw a portion of territory, land, or site.

.3. Sketch:

A rough drawing representing the chief features of an object or scene and often made as a preliminary study, or a tentative draft.

.4. Perspective:

Out of Latin: *prospic re*, to look forward. **1.** Any method or technique employed to depict volumes and spatial relationships on a flat surface or to represent three-dimensional space on a flat surface or in relief sculpture. The linear central perspective, is a PROJECTION (AXE 4) on a plan of a visual frame according to a viewpoint, it is a conquest of the first Florentine Renaissance. It consciously regarded only the arts operating on flat surfaces such as drawings and paintings; suddenly it became useful to architecture to spatially clarify its constructive projects, as well as existing buildings.

.5. Projection:

Out of Latin: *proic re*, to throw forward. **1**. It is a fundamental operation of DESCRIPTIVE GEOMETRY. It consists in connecting a PROJECTIVE CENTRE with the main points of an object, prolonging such lines through the PROJECTION PLAN (VISUAL PLAN IV 2) practically the DRAWING sheet. The

.6. *Axe:* O

.7. *Axonometric drawing:* O

° in between z and y, the resulting axonometric drawing or projection is called military.

.8. *Isometric:*	Drafting, designating a method of projection, ISOMETRIC PROJECTION, in which a three-dimensional object is REPRESENTED by a drawing, ISOMETRIC DRAWING, having the horizontal edges of the object drawn usually at a 30° angle and all verticals projected perpendicularly from a horizontal base, all lines being drawn to scale [METRICAL SCALE]. Cf. ORTHOGRAPHIC PROJECTION. It is also called military perspective. This is giving a more realistic effect respect to the other kinds of axonometric drawings or prospective systems, diagonals and curves result to be deviate (PROJECTION).
.9. *Development:*	Form of architectonic REPRESENTATION in which views of internal environments, buildings, streets surrounded by buildings, or squares, are turned over horizontally, as being represented on a sheet so that they can be cut out.
.10. *Executive drawing:*	A drawing designed for or relating to execution or carrying into effect.
.11. *Metrical scale:*	Indicates the ratio used by an architectonic representation or model to reduce (or multiply) the real measures. The commonly used M. S. are: for DETAILS 1:1, 1:5 (1 drawn cm corresponds to 5 cm of the real length), 1:10, 1:20; for constructive plans, 1:50, 1:100, 1:200; for PLANIMETRIC SKETCHES, 1:500; for GENERAL PLANIMETRIES, 1:500, 1:1000, 1:2500, 1:5000; for TOPOGRAPHICAL MAPS, 1:10000.
.12. *Planimetry:*	Properly, topographical representation that is not considering the quote differences; it is often used in town planning, even if sometimes the quote differences are indicated.
.13. *Planimetric sketches….*	A rough drawing representing the chief features of a planimetry and often made as a preliminary study, or a tentative draft.
.14. *Plan:*	It is a horizontal SECTION through a building. It is usually made at the height of windows; it gives a REPRESENTATION in orthogonal PROJECTION of the position and spaciousness of a floor rooms, as well as the number and dimension of doors, stairways etc.; yet never their own heights.
.15. *Sections:*	Out of Latin: *secare*, to cut. When an object, for example a building, is sawn along a plan called *sectioning*, the common points determine, in an architectonic REPRESENTATION, a section. It can be horizontal and thus called PLAN; or *vertical* (*longitudinal* or *transversal*), the most frequent; and also

oblique (for example a vertical section, that allows the study of interiors also through the aid of the AXONOMETRIC DRAWING). Also a FRONT ELEVATION can be considered a vertical section on the façade plan. Sections are indispensable for studying and understanding the spatial relations into a building. Sections are not to be confused with their PROFILE

.16. - elevation:

A geometrical projection on a vertical plane of a special façade; there are different kind of elevations: according to the different façade projected.

.17. Profile:

A side or sectional elevation: as a drawing showing a vertical section of the ground; a vertical section of a soil from the ground surface to the underlying unweathered material.

.18. Restoration:

An act of restoring or the condition of being restored: as **a :** a bringing back to a former position or condition; a restoring to an unimpaired or improved condition <the *restoration* of a building>.

.19. Descriptive Geometry:[2]

Branch of geometry concerned with the two-dimensional representation of three-dimensional objects; it was introduced in 1795 by Gaspard Monge. By means of such representations, geometrical problems in three dimensions may be solved in the plane. (Such problems arise in all branches of engineering.) Modern mechanical drawing and architectural drawing are based on the principles of descriptive geometry.

.20. Geometry:[3]

Out of Greek: geo-metros, earth measuring, branch of mathematics concerned with the properties of and relationships between points, lines, planes, and figures and with generalisations of these concepts.

Types of Geometry

Euclidean geometry, elementary geometry of two and three dimensions (plane and solid geometry), is based largely on the *Elements* of the Greek mathematician Euclid (fl. c.300 BC). In 1637, René Descartes showed how numbers can be used to describe points in a plane or in space and to express geometric relations in algebraic form, thus founding analytic geometry, of which algebraic geometry is a further development (see Cartesian co-ordinates). The problem of representing three-dimensional objects on a two-dimensional surface was solved by Gaspard Monge, who invented descriptive geometry for this purpose in the late 18th century; differential geometry, in which the concepts of the calculus are applied to curves,

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[2] Out of *The Columbia Encyclopædia*, Fifth Edition 1993, Columbia University Press.

[3] Ibiden / See H. G. Forder, *The Foundations of Euclidean Geometry* (1927); H. S. M. Coxeter, *Introduction to Geometry* (2d ed. 1969).

surfaces, and other geometrical objects, was founded by Monge and C. F. Gauss in the late 18th and early 19th cent. The modern period in geometry begins with the formulations of projective geometry by J. V. Poncelet (1822) and of non-Euclidean geometry by N. I. Lobachevsky (1826) and János Bolyai (1832). Another type of non-Euclidean geometry was discovered by Georg Riemann (1854), he also showed how the various geometries could be generalised to any number of dimensions.

Their Relationship to Each Other

The different geometries are classified and related to one another in various ways. The non-Euclidean geometries are exactly analogous to the geometry of Euclid, except that Euclid's postulate regarding parallel lines is replaced and all theorems depending on this postulate are changed accordingly. Both the Euclidean and non-Euclidean geometry are types of metric geometry, in which the lengths of line segments and the sizes of angles may be measured and compared. Projective geometry, on the other hand, is more general and includes the metric geometries as a special case; pure projective geometry makes no reference to lengths or angle measurements.

The general metric geometry consisting of all of Euclidean geometry except that part dependent on the parallel postulate is called absolute geometry; its propositions are valid for both Euclidean and non-Euclidean geometry. Another type of geometry, called affine geometry, includes Euclid's parallel postulate but disregards two other postulates concerning circles and angle measurement; the propositions of affine geometry are also valid in the four-dimensional geometry of space-time used in the theory of relativity. Ordered geometry consists of all propositions common to both absolute geometry and affine geometry; this geometry includes the notion on intermediacy (“between-ness”) but not that of measurement.

An important step in recognising the connections between the different types of geometry was the Erlangen program, proposed by the German Felix Klein in his inaugural address at the Univ. of Erlangen (1872), according to which geometries are classified with respect to the geometrical properties that are left unchanged (invariant) under a given group of transformations. For example, Euclidean geometry is the study of properties unchanged by similarity transformations, affine geometry is concerned with properties invariant under the linear transformations (affine collineations) that preserve parallelism, and projective geometry studies invariants under the more general projective transformations (collineations and correlations). Topology, perhaps the most general type of geometry although often considered a separate branch of mathematics, is concerned with properties that are invariant under continuous transformations, which carry neighbourhoods of points into neighbourhoods of their images.

The Axiomatic Approach to Geometry

Euclid's *Elements* organised the geometry then known into a systematic presentation that is still used in many texts. Euclid first defined his basic terms, such as point and line, then stated without proof certain axioms and postulates about them that seemed to be self-evident or obvious truths, and finally derived a number of statements (theorems) from the postulates by means of deductive logic. This axiomatic method has since been adopted not only throughout mathematics but in many other fields as well. The close examination of the axioms and postulates of Euclidean geometry during the 19th century resulted in the realisation that the logical basis of geometry was not as firm as had previously been supposed. Various mathematicians developed new axiom and postulate systems, notably David Hilbert (1899).

.21. Mathematics:[4]

Deductive study of numbers, geometry, and various abstract constructs, or structures; the latter often “abstract” the features common to several models derived from the empirical, or applied, sciences, although many emerge from purely mathematical or logical considerations. Mathematics is very broadly divided into foundations, algebra, analysis, geometry, and applied mathematics, which includes theoretical computer science.

Branches of Mathematics

Foundations

The term *foundations* is used to refer to the formulation and analysis of the language, axioms, and logical methods on which all of mathematics rests (see logic; symbolic logic). The scope and complexity of modern mathematics requires a very fine analysis of the formal language in which meaningful mathematical statements may be formulated and perhaps be proved true or false. Most apparent mathematical contradictions have been shown to derive from an imprecise and inconsistent use of language. A basic task is to furnish a set of axioms effectively free of contradictions and at the same time rich enough to constitute a deductive source for all of modern mathematics. The modern axiom schemes proposed for this purpose are all couched within the theory of sets, originated by Georg Cantor, which now constitutes a universal mathematical language.

Algebra

Historically, algebra is the study of solutions of one or several algebraic equations, involving the polynomial functions of one or several variables. The case where all the polynomials have degree one (systems of linear equations) leads to linear algebra. The case of a single equation, in which one studies the roots of one polynomial, leads to field theory and to the so-called Galois theory. The general case of several equations of high degree leads to algebraic geometry, so named because the sets of solutions of such systems are often studied by geometric methods.

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[4] Ibiden / See Richard Courant and Herbert Robbins, *What Is Mathematics?* (1941); E. T. Bell, *The Development of Mathematics* (2d ed. 1945) and *Men of Mathematics* (1937, rep. 1961); J. R. Newman, ed., *The World of Mathematics* (4 vol., 1956); E. E. Kramer, *The Nature and Growth of Mathematics* (1970); Morris Kline, *Mathematical Thought from Ancient to Modern Times* (1973); D. J. Albers and G. L. Alexanderson, eds., *Mathematical People* (1985).

Modern algebraists have increasingly abstracted and axiomatised the structures and patterns of argument encountered not only in the theory of equations, but in mathematics generally. Examples of these structures include groups (first witnessed in relation to symmetry properties of the roots of a polynomial and now ubiquitous throughout mathematics), rings (of which the integers, or whole numbers, constitute a basic example), and fields (of which the rational, real, and complex numbers are examples). Some of the concepts of modern algebra have found their way into elementary mathematics education in the so-called new mathematics.

Some important abstractions recently introduced in algebra are the notions of category and functor, which grew out of so-called homological algebra. Arithmetic and number theory, which are concerned with special properties of the integers—e.g., unique factorisation, primes, equations with integer coefficients (Diophantine equations), and congruencies—are also a part of algebra. Analytic number theory, however, also applies the non-algebraic methods of analysis to such problems.

Analysis

The essential ingredient of analysis is the use of infinite processes, involving passage to a limit. For example, the area of a circle may be computed as the limiting value of the areas of inscribed regular polygons as the number of sides of the polygons increases indefinitely. The basic branch of analysis is the calculus. The general problem of measuring lengths, areas, volumes, and other quantities as limits by means of approximating polygonal figures leads to the integral calculus. The differential calculus arises similarly from the problem of finding the tangent line to a curve at a point. Other branches of analysis result from the application of the concepts and methods of the calculus to various mathematical entities. For example, vector analysis is the calculus of functions whose variables are vectors. Here various types of derivatives and integrals may be introduced. They lead, among other things, to the theory of differential and integral equations, in which the unknowns are functions rather than numbers, as in algebraic equations. Differential equations are often the most natural way in which to express the laws governing the behaviour of various physical systems. Calculus is one of the most powerful and supple tools of mathematics. Its applications, both in pure mathematics and in virtually every scientific domain, are manifold.

Geometry

The shape, size, and other properties of figures and the nature of space are in the province of geometry. Euclidean geometry is concerned with the axiomatic study of polygons, conic sections, spheres, polyhedra, and related geometric objects in two and three dimensions—in particular, with the relations of congruence and of similarity between such objects. The unsuccessful attempt to prove the “parallel postulate” from the other axioms of Euclid led in the 19th century to the discovery of two different types of non-Euclidean geometry.

The 20th century has seen an enormous development of topology, which is the study of very general geometric objects, called topological spaces, with respect to relations that are much weaker than congruence and similarity. Other branches of geometry include algebraic geometry and differential geometry, in which the methods of analysis are brought to bear on geometric problems. These fields are now in a vigorous state of development.

Applied Mathematics

The term "*applied mathematics*" loosely designates a wide range of studies with significant current use in the empirical sciences. It includes numerical methods and computer science, which seeks concrete solutions, sometimes approximate, to explicit mathematical problems (e.g., differential equations, large systems of linear equations). It has a major use in technology for modelling and simulation. For example, the huge wind tunnels, formerly used to test expensive prototypes of aeroplanes, have all but disappeared. The entire design and testing process is now largely carried out by computer simulation, using mathematically tailored software. It also includes mathematical physics, which now strongly interacts with all of the central areas of mathematics. In addition, probability theory and mathematical statistics are often considered parts of applied mathematics. The distinction between pure and applied mathematics is now becoming less significant.

Development of Mathematics

The earliest records of mathematics show it arising in response to practical needs in agriculture, business, and industry. In Egypt and Mesopotamia, where evidence dates from the 2d and 3d millennia BC, it was used for surveying and mensuration; estimates of the value of (pi) are found in both locations. There is some evidence of similar developments in India and China during this same period, but few records have survived. This early mathematics is generally empirical, arrived at by trial and error as the best available means for obtaining results, with no proofs given. However, it is now known that the Babylonians were aware of the necessity of proofs prior to the Greeks, who had been presumed the originators of this important step.

Greek Contributions

A profound change occurred in the nature and approach to mathematics with the contributions of the Greeks. The earlier (Hellenic) period is represented by Thales (6th cent. BC), Pythagoras, Plato, and Aristotle, and by the schools associated with them. The Greeks discovered the Pythagorean theorem, known earlier in Mesopotamia, during this period.

During the Golden Age (5th cent. BC), Hippocrates of Chios made the beginnings of an axiomatic approach to geometry and Zeno of Elea proposed his famous paradoxes concerning the infinite and the infinitesimal, raising questions about the nature of and relationships among points, lines, and numbers. The discovery through geometry of irrational numbers, such as the square root of, also dates from this period. Eudoxus of Cnidos (4th cent. BC) resolved certain of the problems by proposing alternative methods to those involving infinitesimals; he is known for his work on geometric proportions and for his exhaustion theory for determining areas and volumes.

The later (Hellenistic) period of Greek science is associated with the school of Alexandria. The greatest work of Greek mathematics, Euclid's *Elements* (c.300 BC), appeared at the beginning of this period. Elementary geometry as taught in high school is still largely based on Euclid's presentation, which has served as a model for deductive systems in other parts of mathematics and in other sciences. In this method primitive terms, such as *point* and *line,* are first defined, then certain axioms and postulates relating to them and seeming to follow directly from them are stated without proof; a number of statements are then derived by deduction from the definitions, axioms, and postulates. Euclid also contributed to the development of arithmetic and presented a geometric theory of quadratic equations.

In the 3d cent. BC, Archimedes, in addition to his work in mechanics, made an estimate of pi and used the exhaustion theory of Eudoxus to obtain results that foreshadowed those much later of the integral calculus, and Apollonius of Perga named the conic sections and gave the first theory for them. A second Alexandrian school of the Roman period included contributions by Menelaus (c. AD 100, spherical triangles), Heron of Alexandria (geometry), Ptolemy (AD 150, astronomy, geometry, cartography), Pappus (3d century, geometry), and Diophantus (3d century, arithmetic).

Chinese and Middle Eastern Advances

Following the decline of learning in the West after the 3d cent., the development of mathematics continued in the East. In China, Tsu Ch'ung-Chih estimated pi by inscribed and circumscribed polygons, as Archimedes had done, and in India the numerals now used throughout the civilised world were invented and contributions to geometry were made by Aryabhata and Brahmagupta (5th and 6th century AD). The Arabs were responsible for preserving the work of the Greeks, which they translated, commented upon, and augmented. In Baghdad, Al-Khowarizmi (9th cent.) wrote an important work on algebra and introduced the Hindu numerals for the first time to the West, and Al-Battani worked on trigonometry. In Egypt, Ibn al-Haytham was concerned with the solids of revolution and geometrical optics. The Persian poet Omar Khayyam wrote on algebra.

Western Development from the 12th to 18th Century

Word of the Chinese and Middle Eastern works began to reach the West in the 12th and 13th cent. One of the first important European mathematicians was Leonardo da Pisa (Leonardo Fibonacci), who wrote on arithmetic and algebra (*Liber abaci*, 1202) and on geometry (*Practica geometriae*, 1220). With the Renaissance came a great revival of interest in learning, and the invention of printing made many of the earlier books widely available. By the end of the 16th century advances had been made in algebra by Niccolò Tartaglia and Geronimo Cardano, in trigonometry by François Viète and in such areas of applied mathematics as mapmaking by Mercator and others.

The 17th cent., however, saw the greatest revolution in mathematics, as the scientific revolution spread to all fields. Decimal fractions were invented by Simon Stevin and logarithms by John Napier and Henry Briggs; the beginnings of projective geometry were made by Gérard Desargues and Blaise Pascal; number theory was greatly extended by Pierre de Fermat; and the theory of probability was founded by Pascal, Fermat, and others. In the application of mathematics to mechanics and astronomy, Galileo and Johannes Kepler made fundamental contributions.

The greatest mathematical advances of the 17th cent., however, were the invention of analytic geometry by René Descartes and that of the calculus by Isaac Newton and, independently, by G. W. Leibniz. Descartes's invention (anticipated by Fermat, whose work was not published until later) made possible the expression of geometric problems in algebraic form and vice versa. It was indispensable in creating the calculus, which built upon and superseded earlier special methods for finding areas, volumes, and tangents to curves, developed by F. B. Cavalieri, Fermat, and others. The calculus is probably the greatest tool ever invented for the mathematical formulation and solution of physical problems.

The history of mathematics in the 18th century is dominated by the development of the methods of the calculus and their application to such problems, both terrestrial and celestial, with leading roles being played by the Bernoulli family (especially Jakob, Johann, and Daniel), Leonhard Euler, Guillaume de L'Hôpital, and J. L. Lagrange. Important advances in geometry began toward the end of the century with the work of Gaspard Monge in descriptive geometry and in differential geometry and continued through his influence on others, e.g., his pupil J. V. Poncelet, who founded projective geometry (1822).

In the 19th Century

The modern period of mathematics dates from the beginning of the 19th century, and its dominant figure is C. F. Gauss. In the area of geometry Gauss made fundamental contributions to differential geometry, did much to found what was first called analysis situs but is now called topology, and anticipated (although he did not publish his results) the great breakthrough of non-Euclidean geometry. This breakthrough was made by N. I. Lobachevsky (1826) and independently by János Bolyai (1832), the son of a close friend of Gauss, whom each proceeded by establishing the independence of Euclid's fifth (parallel) postulate and showing that a different, self-consistent geometry could be derived by substituting another postulate in its place. Still another non-Euclidean geometry was invented by G. F. B. Riemann (1854), whose work also laid the foundations for the modern tensor calculus description of space, so important in the general theory of relativity.

In the area of arithmetic, number theory, and algebra, Gauss again led the way. He established the modern theory of numbers, gave the first clear exposition of complex numbers, and investigated the functions of complex variables. The concept of number was further extended by W. R. Hamilton, whose theory of quaternions (1843) provided the first example of a non-commutative algebra (i.e., one in which ab /= ba). This work was generalised the following year by H. G. Grassmann, who showed that several different consistent algebras might be derived by choosing different sets of axioms governing the operations on the elements of the algebra.

These developments continued with the group theory of M. S. Lie in the late 19th century and reached full expression in the wide scope of modern abstract algebra. Number theory received significant contributions in the latter half of the 19th century through the work of Georg Cantor, J. W. R. Dedekind, and K. W. Weierstrass. Still another influence of Gauss was his insistence on rigorous proof in all areas of mathematics. In analysis this close examination of the foundations of the calculus resulted in A. L. Cauchy's theory of limits (1821), which in turn yielded new and clearer definitions of continuity, the derivative, and the definite integral. A further important step toward rigor was taken by Weierstrass, who raised new questions about these concepts and showed that ultimately the foundations of analysis rest on the properties of the real number system.

In the 20th Century

In the 20th century the trend has been toward increasing generalisation and abstraction, with the elements and operations of systems being defined so broadly that their interpretations connect such areas as algebra, geometry, and topology. The key to this approach has been the use of formal axiomatics, in which the notion of axioms as “self-evident truths” has been discarded. Instead the emphasis is on such logical concepts as consistency and completeness. The roots of formal axiomatics lie in the discoveries of alternative systems of geometry and algebra in the 19th cent.; the approach was first systematically undertaken by David Hilbert in his work on the foundations of geometry (1899).

The emphasis on deductive logic inherent in this view of mathematics and the discovery of the interconnections between the various branches of mathematics and their ultimate basis in number theory led to intense activity in the field of mathematical logic after the turn of the century. Rival schools of thought grew up under the leadership of Hilbert, Bertrand Russell and A. N. Whitehead, and L. E. J. Brouwer. Important contributions in the investigation of the logical foundations of mathematics were made by Kurt Gödel and A. Church.

2. Geometry to Computer Graphics:

.22. Working in 2D and 3D:

In this very first approach we will start by giving a wide view by starting from 2D, to then arrive to 3D.

The CAD applications for two-dimensional purposes are, from a conceptual viewpoint, more similar than we could be expecting to the traditional drawing systems.

2D designing software is not much different from the traditional drawing table and the technical drawing table. The 2D CAD gives the operator a plan sheet on which it is possible to draw geometric representations, just the same way as with a normal pencil; the only difference is on the possibility of perusing the modern technology to speed up and made the result more precise. It is clear that in this case, by operating on a plan, points are defined by just two co-ordinates (x and y).

To draw an object in 3D means a completely different approach; it requires our imagination an effort to get over the limitation given by the plan representation visualised by the monitor. To use 3D software means to work in a spatial simulation of the real space where each point is defined by three variables (x, y, and z). Let us imagine being into a room and being asked to assemble a piece of furniture by building up all its different parts, we will be able to turn around the objects and to watch them from different views while building the piece of furniture up. Coming back to the 3D software, we will act the same way round. To work in a 3D environment means to model or to assemble an object as on a working table. We will be having the possibility of watching it on plans, sections, frontally, laterally, in an axonometry, etc.. But all of the previous should not generate any confusion, being all those views just different views of the same model, used and useful to run the task, that unluckily cannot be visualised otherwise than on a screen. By keeping in mind this concept, each and any thing we will draw in plan, frontal view or axonometry, will be placed and will influence the three dimensional space that represent Your scene/set. Modern virtual reality systems allow plunging experiences, which facilitate and speed up the understanding of our work.

.23. *Geometrical reference systems:*

CAD programs work referring to a Cartesian Orthogonal co-ordinate system, in which each and any point is individuated through a co-ordinates tern (x, y, and z). It must be said that some programs also allow temporal, characteristic, parameters or other representations, by mean of other co-ordinates. By that representing a multi dimensional system. Drawn forms, by easily selecting designed tools, are then generated by mathematical equations describing the course of a geometric function representative of that entity, and based on our inputs. For example, when we are drawing a line, software is asking for some basic information (in terms of co-ordinates or selected points) starting from which it will build up the drawing. These applications usually use a general co-ordinates system on which multiple and different particular systems can be defined, this is to facilitate the creation of geometrical entities into an existing system. When it is necessary to insert a new solid on a parallelepiped, it is though to be easier to define a local reference system, with its origin in one of the object upper corners, rather than drawing the new entity in the general system and then locating it on the desired face. The only problem of this system is that before starting to draw it is advisable to check which of the reference system is active (UCS).

.24. *Basic Geometric Entities:*

It must be said that it is not possible in this short introduction to define exhaustively the subject, but we will try to give a general view of the used geometric entities in CAD.

Point: as already mentioned two or three co-ordinates define it, it represents the smallest geometrical entity. Its definition is usually by mean of direct selection (mouse or graphic tablet) or by specifying its co-ordinates. All the geometric entities will be originated from one or more points.

Line: it is described by a very simple equation, to draw it, only two points are needed; those are generically defined as initial p. and final p.

Polyline 2D: It is a continuous succession of lines and it is defined through the selection of points. The number of segments composing it is unlimited, generally at every selection, the used software allows the choice of closing the geometry or going on by selecting another point. It is important to stress that: in case the polyline would be used to generate a solid, it must be closed.

Polyline 3D: it is defined as the 2D version, but the points composing it can be on different plans, thus being defined by three variables instead of two. Even if it is in a three-dimensional space, this geometry does not have any depth.

Curves: simple curves are defined by selecting an initial and a final point, however, to build particular profiles, it is possible to choose the tracing option based upon three points.

Splines / Bezier Curves: Those are curves obtained through the use of mathematical functions, which connect several points through a progressive junction. They are characterised by the possibility of creating a great number of complex free forms by taking just a few reference points.

Regular and irregular finite geometries: in this case the reference is to particular functionalities that allow to immediately obtain regular or irregular geometric shapes (circle, square, triangle, etc.).

Mesh 2D 3D: It is each and any geometry traced by a mesh of connected points. A Mesh is defined starting by two or more polylines or reference curves; even being a 3D entity, it does not have any depth.

3D solid generated by extruding 2D geometry along a direction. Its characteristic is to be the only geometric entity having three dimensions (height, width, and depth) those can be comparable to the real ones.

.25. Computer Graphics and Geometry:

C Programming Language. Graphical input and output devices, graphical problems, the GKS graphics standard. Co-ordinate systems, co-ordinate system transformations, point transformations (homogeneous co-ordinates, transformation groups). Mapping of space onto plane (axonometric drawing, parallel and central projections), matrix representation of mappings. Description of curves (different representations) interpolating curves: Hermite arc, Overhauser spline, Ferguson spline; approximating curves: Bézier curve (de Casteljau algorithm, parametric form, properties), B-spline (definition, properties). Description of surfaces, interpolating and approximating surfaces: bilinearly and bicubically blended Coons patches, Bézier surfaces and B-spline patches.

.26. Interactive CAD/CAM Systems:

Constructional design process, computer aided functions of the process. Building of interactive design systems. Hardware and software tools. Usage of geometric data for strength (i.e. FEM), technological (ie. CAM) etc. tasks. Macro, variant and parametric procedures. Development of program systems. Theory of design for correct manufacturing, computer aided design for correct manufacturing. The influence of competitiveness on constructional design. Quality development software and constructional design software, relations between them. Application of expert systems in constructional design.

.27. Geometric Modelling:

Solid modelling methods: wireframe, Boundary representation (B-rep), Constructive Solid Geometry (CSG), cellular methods. Models input and modification. Rendering of solids: hidden line elimination (painter's algorithm, z-buffer, ray tracing), lighting and shading models

(Gouroud, Phong). Rational Bézier curve, rational B-spline, description of free form surfaces (NURBS patches).

3. Reproduction processes:[5]

.1. *Blueprint:*

A type of print used for copying engineering drawings and similar material. The name is popularly applied to two separate methods, more exactly designated as the blueprint and the whiteprint, or diazotype. In blueprinting, the older method, the drawing to be copied, made on translucent tracing cloth or paper, is placed in contact with paper sensitised with a mixture of ferric ammonium citrate and potassium ferricyanide, which is then exposed to light. In the areas of the sensitised paper not obscured by the lines of the drawing, the light reduces the ferric salt to the ferrous state, in which it reacts with the potassium ferricyanide to form insoluble Prussian blue. The exposed paper is then washed in water, producing a negative in which the lines of the drawing appear in white against a dark blue background.

In the whiteprinting method, the paper is sensitised with a mixture of a diazonium salt, a coupler that reacts with the diazonium salt to form an azo dye, and an acid that prevents coupling. Exposure to light destroys the diazonium salt. Final treatment with an alkaline agent, such as ammonia gas, neutralises the acid, thereby bringing about the coupling reaction. Because it produces dark lines on a "white" or light background, whiteprinting has become the favoured method.

.2. *Typographic printing:*

Also called letterpress printing or also called RELIEF PRINTING, in commercial printing, process by which many copies of an image are produced by repeated direct impression of an inked, raised surface against sheets or a continuous roll of paper. Letterpress is the oldest of the traditional printing techniques and remained the only important one from the time of Gutenberg, about 1450, until the development of lithography late in the 18th century and, especially, offset lithography early in the 20th.

Originally the ink-bearing surface for printing a page of text was assembled from individual types by a typesetter or compositor, letter by letter and line by line. The first keyboard-actuated typesetting machines, the Linotype and the Monotype, were introduced in the 1890s. If only a small number of copies is to be made, printing can be done directly from the hand- or machine-set blocks of type assembled in

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[5] draftingDuplication of drawings
http://search.britannica.com/bcom/eb/article/4/0,5716,108944+13,00.html

forms, but for long press runs, duplicates--stereotypes or electrotyping--are made to prevent wear and damage of the expensive types.

Letterpress was originally carried out on platen presses, in which the paper is pressed against the flat, inked form by a flat platen; later, the platen was replaced by a roller in the flat-bed cylinder press; still later, the printing form was wrapped around one cylinder and the paper was passed between this cylinder and a second, creating a rotary press (*see* printing).

Several procedures have been developed for the production of line drawings or reproduction of photographs in the form of halftone pictures by letterpress. The most widely used method of preparing a printing plate for such matter is photoengraving.

Letterpress can produce work of high quality at high speed, but it requires much time to adjust the press for varying thicknesses of type, engravings, and plates. Because of the time needed to make letterpress plates and to prepare the press, many newspapers have changed to offset printing. To combat this trend, letterpress printers have developed printing plates made from a photosensitive plastic sheet that can be mounted on metal. *See also* flexography.

.3. *Re drafting on original drawings:*

.4. *Re drafting on copies:*

.5. *Engraving:*[6]

In its broadest sense, the art of cutting lines in metal, wood, or other materials either for decoration or for reproduction through *printing*. In its narrowest sense, it is an *intaglio* printing process in which the lines are cut in a metal plate with a graver, or burin. Furrows are cleanly cut out, raising no burr, and then filled with ink which is transferred under high pressure to the printing surface of the press. The earliest known engravings printed on paper date from about the middle of the 15th cent. Among the early master engravers were Dürer, Schongauer, and Lucas van Leyden. Wood engraving differs from true engraving in that it is a relief process. During the 19th century, steel engraving enjoyed a short popularity as a reproduction process because it made possible a large number of proofs, but it was superseded by photomechanical processes (see photoengraving). See also drypoint, etching, and mezzotint.

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[6] Ibiden / See A. M. Hind, *History of Engraving and Etching* (1923, repr. 1963); A. Gross, *Etching, Engraving, and Intaglio Printing* (1970); G. Duplessis, *Wonders of Engraving* (1989).

.6. Printing:[7]

Means of producing reproductions of written material or images in multiple copies. There are four traditional types of printing: relief printing (with which this article is mainly concerned), intaglio, lithography, and screen process printing. Relief printing encompasses type, stereotype, electrotype, and letterpress. Flexographic printing is a form of rotary letterpress printing using flexible rubber plates and rapid-drying inks.

For an account of type design, see type; typography. See also book; bookbinding.

. 1. Relief Printing:

Early History

The story of the invention of printing and of its early days is told in the article type. In the 15th century the art spread, directly and indirectly, from Mainz to many parts of Europe. William Caxton brought it to England in 1476; Juan Pablos, who set up his press in Mexico City to the New World in 1539.

Mechanisation

The first papermaking machine producing a continuous roll of paper and capable of delivering sheets in specific sizes—the Fourdrinier machine—was installed in London in 1803. Friedrich Koenig, a German, successfully applied steam power to the printing press in 1810. The invention did not improve the quality of the product but greatly increased the output of the machine. In Koenig's press, the type bed remained flat as in hand presses, but the paper was pressed on the type by a cylinder. An American, Isaac Adams invented the Adams power press, in 1827.

In 1846 and 1847, Richard March Hoe designed a rotary press in which stereotype plates were for the first time arranged in a true cylinder. In 1866 a press known later as the Walter press was patented in England; in this press the printing surfaces were not types but stereotype plates curved to form parts of cylinders. The invention of ways of making paper in sheets of any desired length, so that paper could be fed to cylinder presses from rolls, assisted in increasing the speed of printing. Machines for folding newspapers were incorporated with the power cylinder press.

Typesetting

Not until the late 19th century were typesetting machines invented. The Linotype machine, invented by Ottmar Mergenthaler in Baltimore in 1884, produced a metal slug corresponding to a single line of type as set by hand in printing. It was first put into operation at the New York *Tribune* in 1886. Operated from a keyboard like that of a typewriter, the machine assembled brass matrices into a line, cast the line, and distributed the matrices. The Intertype machine was substantially similar to the Linotype machine, and the matrices made by either machine could be used in the other.

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[7] Ibiden /

The third principal typesetting machine is the Monotype, patented by Tolbert Lanston in 1887 and first produced commercially in 1897. The Monotype makes each character separately, assembling the characters as in hand composition, for which the Monotype characters can be used. Before electronic composition, monotype had an advantage in setting certain kinds of copy, e.g., mathematical and scientific material, where special symbols or other problems may be involved.

.7. *Intaglio:*[8]

Design cut into stone or other material or etched or engraved in a metal plate, producing a concave, instead of a convex, effect. It is the reverse of a relief or cameo. The term also designates a gem so cut. Seals and signet rings usually bear intaglio designs, so that when stamped upon wax or other plastic substance the impression is in relief. See engraving; etching; printing.

In intaglio printing, such as the etching and the steel engraving, the design to be printed is lower than the surface of the plate, which is wiped clean before each impression, leaving the incised design filled with ink, which the paper receives. In gravure intaglio printing, tone is produced by varying the thickness of the ink of the printing surface through depressions of varying depth; minute points constitute the clean surface that keeps the paper from being pressed into the depressions. In photogravure a photographic process makes the gravure plate. Rotogravure is photogravure adapted for printing by a rotary or cylinder press.

.8. *Lithography:*[9]

Type of planographic or surface printing. It is distinguished from letterpress (relief) printing and from intaglio printing (in which the design is cut or etched into the plate). Lithography is used both as an art process and as a commercial printing process. In commercial printing the term is used synonymously with offset and litho-offset printing, offset lithography, and Photolithography. Collotype, also called photogelatine, is also a lithographic process.

The Process

All planographic printing is based on chemical action, and lithography is based on the mutual antipathy of oil and water. As the name [from Greek = writing on stone] implies, a lithograph is printed from a stone (except in commercial processes, where a variety of thin grained metal, plastic, and paper plates are now also employed). The process was invented c.1796 by the playwright Aloys Senefelder,

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[8] Ibiden /

[9] Ibiden / See Joseph Pennell and Elizabeth Pennell, *Lithographs and Lithographers* (1915); V. Strauss, *Lithographers Manual* (2 vols. 1958); W. Weber, *A History of Lithography* (1966); F. H. Man, *Artists' Lithographs: A World History* (1970).

and the Bavarian limestone that he employed is still considered the best material for art lithography.

The slab of stone is ground to a level surface, which may be of coarse or fine texture as desired. The drawing is made in reverse directly on the stone with a lithographic crayon or ink that contains soap or grease. The fatty acid of this material interacts with the lime of the stone to form insoluble lime soap on the surface, which will accept the greasy printing ink and reject water. Accordingly, those parts of the stone that have been drawn upon have an affinity for ink.

Sometimes the drawing is made on paper and transferred to a heated stone by pressure. This is known as a transfer lithograph and does not require the artist to reverse his or her drawing. Next, the surface of the stone untouched by grease is desensitised to it, and the portions drawn upon are fixed against spreading by treatment with a gum Arabic and nitric acid solution. The grease has now penetrated the stone, and the drawing is washed off with turpentine and water. The stone is ready to be inked with a roller and printed, but it must be kept moist. The printing requires a special lithographic press with a sliding bed passing under a scraper.

Commercial printing such as offset and litho-offset printing, offset lithography, and Photolithography are based on a modification of the lithographic press featuring a rubber-covered cylinder between the printing cylinder and the impression cylinder. The plate cylinder transfers the image to the rubber blanket cylinder, which in turn offsets it on the paper carried by the impression cylinder. Offset and other forms of planographic printing, through many technical refinements, make it possible to increase production speeds, to improve quality in the reproduction of fine tones, and to substantially reduce the number of impressions required to reproduce full-colour copies.

Collotype uses a gelatine-faced plate to achieve the tonal distribution obtained through screen dots in engraving. It is chiefly used in the reproduction of fine illustrations or of scientific subject matter requiring accuracy of detail.

Applications

As printing process lithography is probably the most unrestricted. It produces tones ranging from intense black to the most delicate grey as well as a full range of colours. It also simulates with equal facility the effects of pencil, pen, crayon, or brush drawing. Scratching through the drawing on the stone readily produces white lines. Several hundred fine proofs can be taken from a stone. Many artists exploited the medium in the 19th century, including Goya, Delacroix, Daumier, Gavarni, Manet, Degas, Bonnard, Whistler, and Toulouse-Lautrec, whose posters are among the most celebrated lithographic masterworks. In the United States, A. B. Davies, George Bellows, Joseph Pennell, and Currier and Ives are among the many artists noted for their lithographs.

For the commercial reproduction of art works, photolithography has played an increasingly important role. In this process a photographic negative is exposed to light over a gelatine-covered paper. Wherever the light does not strike the gelatine, the latter remains soluble while the other parts are rendered insoluble. When the soluble portions are washed away, the pattern to be printed can be inked and transferred to the stone or plate. Colour lithography and colour photolithography requires as many stones or plates, as the number of colours employed. The commercial printing applications of the lithographic process are vast in scope and almost unlimited in number.

.9. *Screen Process:*[10]

The fourth traditional type of printing, screen process, includes silk screen and has special applications in the printing industry. Silk screen-printing is a form of stencil printing, i.e., printing where the ink is applied to the back of the image carrier and pushed through porous or open areas. The image is on a piece of silk stretched on a frame and backed by a rubber squeegee containing ink. The nonprinting areas on the silk screen are blocked out, and the ink is pushed through the porous areas corresponding to the design; the process is widely used for posters and for printing on glass, plastics, and textured surfaces. Mimeographing is another commercial application of stencil printing.

Illustrations and Colour Printing

In three kinds of printing—relief, intaglio, and planographic—illustrations are often produced by the halftone process, in which a plate is made by photographing through glass marked with a network of fine lines (see also photoengraving). A usual form of colour printing is by the Ben Day, or Benday, process, invented by New York printer Benjamin Day, which utilises celluloid sheets to achieve proper shading and colour. Printing in colours is sometimes done, as excellently in Japan, by applying inks of different colours by hand to the printing surface, but usually a separate printing surface is used for each ink.

In full-colour printing four standard colours are used—yellow, cyan (a hue between blue and green), magenta, and black—the first three being the complementary colours of blue, red, and green. Printing one colour over another produces other colours: e.g. green is produced by printing cyan on yellow. Black is used to print the text accompanying the illustration, and it is often used as a fourth colour in the illustration itself to add strength and detail.

Modern Innovations

In recent years the use of photographic processes has expanded greatly, and the development of electronic devices, as well as other technological advances, has introduced a new era in the evolution of printing. The development of typewriters

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[10] Ibiden / An excellent selected bibliography is Hellmut Lehmann-Haupt, *One Hundred Books about Bookmaking* (1949). See Warren Chappell, *A Short History of the Printed Word* (1970); Lucien Febvre and Henri-Jean Martin, *The Coming of the Book* (1976); Elizabeth Eisenstein, *The Printing Press as an Agent of Change* (1979).

and personal computers capable of delivering justified and proportionally spaced copy has made possible the production of camera-ready books and has met the demands for several special types of printing.

Perhaps the most revolutionary innovation has been the introduction of photocomposition machines for setting type by photographic means. Two of these are analogous in principle to the Monotype and Intertype casting machines and has been produced by the respective companies under the trademarks of Monophoto and Intertype Fotosetter. The Linofilm is a phototypesetting machine developed by the Linotype Corporation. The Photon machine, invented by the Frenchmen René Higonnet and Louis Moyroud, using an electric typewriter connected with a computer and a photographing unit, is noteworthy. Almost exclusively electronic, it can deliver justified type on film in a wide variety of styles at extraordinary speed.

Today photocomposition has been adopted in lithography, gravure, and letterpress printing, and its use, together with other electronic techniques, has revolutionised the printing industry (see optical sensing). In recent years some newspapers have started to use pagination systems, in which newspapers are electronically composed by computer, outputted to a negative, and a plate is made of the negative.

Many reproduction processes other than those cited above have also been developed. Xerography, or electrostatic printing, has been widely adopted for duplicating purposes. It is an effective means of producing master plates for offset printing. One xerographic device is used for making full-size reprints of out-of-print books from microfilm. Other duplicating processes of commercial importance are the Multigraph, which operates on the letterpress principle; the Multilith, basically a small offset press; the Ditto, a duplicator using a special fluid to remove ink from the master plate and transfer it to the paper; and the well-known Photostat process. A multitude of office copying machines using a wide variety of chemical and mechanical processes has been developed in recent years.

.10.. Etching:[11]

The art of engraving with acid on metal; also the print taken from the metal plate so engraved. In hard-ground etching the plate, usually of copper or zinc, is given a thin coating or ground of acid-resistant resin. This is sometimes smoked so that lines scratched through the resin will be clearly visible. A needle exposes the metal without penetrating it. When the design is completed, the plate is submerged in an acid solution that attacks the exposed lines. During the bath the plate is frequently removed, and such lines as are bitten to sufficient depth are coated with stopping-out varnish. The lines receiving the longest exposure to the acid will be the heaviest and darkest in the print. It is also possible to apply the acid locally to the plate. In printing, all varnish is removed, the plate is warmed, coated with etcher's ink, and then carefully wiped so that the ink remains in the depressions but is largely or wholly removed from the surface. It is then covered

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[11] Ibiden / See A. M. Hind, *A History of Engraving and Etching* (rev. ed. 1963); Joseph Pennell, *Etchers and Etching* (1919); A. Gross, *Etching, Engraving, and Intaglio Printing* (1970); Walter Chamberlain, *The Thames and Hudson Manual of Etching and Engraving* (1978).

with a soft, moist paper and run through an etching press. There are many variations in the technique of etching. Etchers often remove undesired lines by burnishing and otherwise change the first state of the plate from which they make their trial print. Certain etchings appear in many and widely different states. Only a limited number of first-rate proofs can be made from a plate, and some etchers destroy their plates after making a given number of prints. Soft-ground etching give effects similar to those obtained in pencil or crayon drawing, while aquatint approximates the effects of a wash drawing. Aquatint is often combined with hard-ground etching, as is also drypoint. This latter technique is not true etching, as no acid is employed; drypoint produces a finer line than does aquatint. Pictorial etching evolved gradually from the earlier burin engraving. Both seem to have originated in Germany, where Dürer's etchings on iron, made between 1510 and 1520, were probably the earliest important examples of an art that in the following centuries was practised by many of the greatest draftsmen and painters. Among the foremost in the history of etching are the works of Dürer, Callot, Rembrandt, the Tiepoli, the Piranesi, Goya, and Whistler.

4. Computer Drafting is based on:[12]

.1. Way of working in a renovation/restoration of buildings:

.2. Drawing precision:

.3. Graphical sign precision:

.4. Technical preparation of draftsman:

.5. Lack of time or haste:

.6. Paper reproduction modalities the first time:

.7. Mistakes gathering:

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[12] draftingDuplication of drawings http://search.britannica.com/bcom/eb/article/4/0,5716,108944+13,00.html http://www.britannica.com/bcom/eb/article/xref/0,5716,15773,00.html