FERNANDO LUIZ LOBO CARNEIRO: A BIOGRAPHICAL NOTE

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Abstract. *Lobo Carneiro, following the indication of Timoshenko in his book: "History of Strength of Materials", attributing to Galileo (1564-1642) the creation of this new discipline, performed an interesting investigation about the role of Galileo in engineering sciences. These studies conducted him to a great contribution to the dimensional analysis and the theory of models, very useful in structural analysis and experimental dynamical behavior of machines.*

Keywords*: History of Education in Brazil, History of Brazilian Engineering, Rio de Janeiro Polytechnic School.*

1. INTRODUCTION

Fernando Luiz Lobo Carneiro (known as Lobo Carneiro), Fig.1, was born in Rio de Janeiro, on January 28, in 1913 and died also in Rio de Janeiro, on November 15, in 2001.

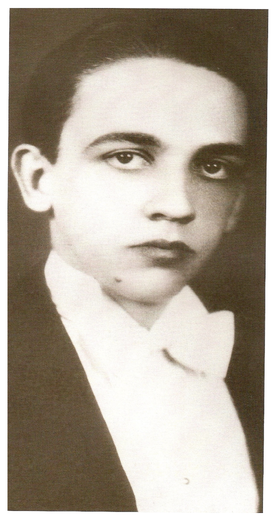


Figure 1. Lobo Carneiro young engineer, in 1934

Son of Aurora Barroso Lobo and Otávio Barboza Carneiro, married on March 25, in 1912. His father had a great influence of positivistic ideas, since the age of seventeen an enthusiastic adept of August Comte (1798-1857). On the other hand his mother encouraged the sons to study music. Hence, he received a good humanistic education and great influence of French culture mainly from the enlightenment and positivist ideas. Early he studied the Greek classics translated to French (Costa, 2005).

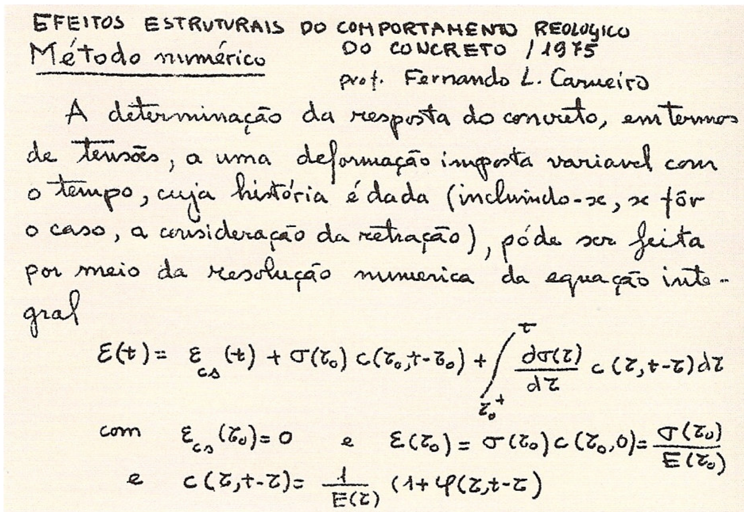
He finished his basic education in "Colégio Rezende" in 1926 with the age of sixteen. At this moment he decided to follow the engineer career and initiated the studies in order to enter in Polytechnic School in Rio de Janeiro, the Brazilian first School of engineering founded in 1810 initially as a military academy by the Portuguese royal court.

In 1935 now as an engineer he accepted the invitation to work in the National Institute of Technology (INT) founded two years before. This important applied research center was created by a group of engineers under the leadership of Ernesto Lopes da Fonseca (1891-1952), all of them polytechnic engineers. Its foundation is an important consequence of the industrialization process in Brazil started by the 1930 Revolution. This new institution was allocated to the new ministry of Labor, Industry and Commerce. Lobo Carneiro began to work in INT on January 1935, in the Division of Materials and Building.

His academic life initiated when in 1968 he became retired from INT and was invited by professor Luiz

Bevilacqua to coordinate Civil Engineering Program of COPPE. In his new job Lobo Carneiro decided to create the biggest structural laboratory of South America. He had a model, the French laboratory of Saint Rémy les Chévreuses where he worked in 1964. In 1972 the laboratory was working as a unique in Brazil.

Then, Lobo Carneiro became lecturer of undergraduated and graduated engineering courses since 1970, having strength of materials and other disciplines of structural engineering as his main field of interest. Later on, he incorporated new methods which appear as result of scientific and technological development. Thus, he spent a lot of time to study finite element method in order to improve your expertise to solve structural problems.


EFEITOS ESTRUTURAIS DO COMPORTAMENTO REOLÓGICO DO CONCRETO / 1975

Método numérico

prof. Fernando L. Carneiro

A determinação da resposta do concreto, em termos de tensões, a uma deformação imposta variavel com o tempo, cuja história é dada (incluindo-se, se fôr o caso, a consideração da retração), póde ser feita por meio da resolução numerica da equação integral

$$\varepsilon(t) = \varepsilon_{cs}(t) + \sigma(\tau_0)\, c(\tau_0, t-\tau_0) + \int_{\tau_0^+}^{\tau} \frac{d\sigma(\tau)}{d\tau}\, c(\tau, t-\tau)\, d\tau$$

com $\varepsilon_{cs}(\tau_0) = 0$ e $\varepsilon(\tau_0) = \sigma(\tau_0)\, c(\tau_0, 0) = \frac{\sigma(\tau_0)}{E(\tau_0)}$

e $c(\tau, t-\tau) = \frac{1}{E(\tau)} (1 + \varphi(\tau, t-\tau))$

Figure 2. Lobo Carneiro's manuscript on rheologic behavior of concrete (1975).

In his researches at INT, Lobo Carneiro developed a new type of test to concrete structures known nowadays as "Brazilian test", which consists to submit a small cylindrical piece of concrete, used as a sample, to compression applied laterally instead of a vertical compression. When this test is performed the cylinder is broken vertically in two pieces and does not present superficial damage concentrated in a small area, as would be expected. This indicated that the sample failure occurred by a tensile stress and not by compression. The test was normalized by the specialized institutions because its better implementation in laboratory and great accuracy. Besides the experimental apparatus Lobo Carneiro developed theoretically the mathematical model based on elasticity theory, which explains the test and postulated a formula to obtain the concrete strength under tensile stress (Borges, 1960).

2. ACADEMIC LIFE

2.1 List of Main Works

"Codes for offshore structures. Design criteria and safety requirements", (Carneiro, 1977).

"Comments on codes for design and construction of fixed steel and concrete offshore structures", (Carneiro, 1979).

"Some aspects of dimensional analysis applied to the theory and the experimentation of offshore platforms", (Carneiro, 1981).

"Offshore engineering and ocean thermal energy conversion", (Carneiro, 1987).

"350 from the Discorsi intorno a due nuove scienze de Galileu Galilei", Rio de Janeiro, (Carneiro, 1989).

"Galileu e os efeitos do tamanho", (Carneiro, 1989).

"Análise dimensional e teoria da semelhança e dos modelos físicos", 1983. (Book).

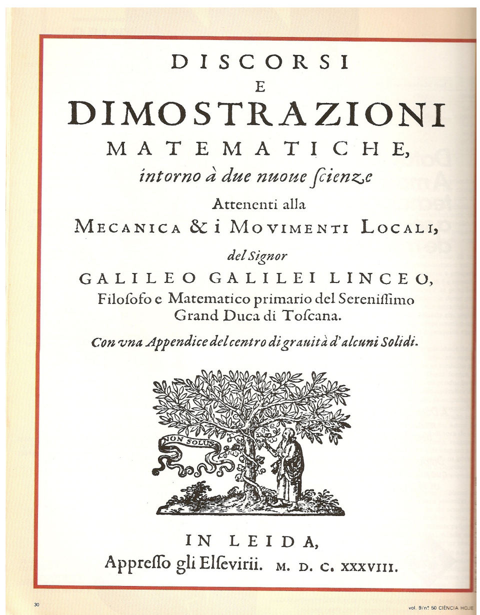
"A experimentação e a técnica na obra de Galileu", (Carneiro, 1995).

"Galilée, fondateur de la resistance des matériaux", (Carneiro, 1997).

"O Instituto Nacional de Tecnologia: indústria e descobertas tecnológicas", 2000.

3. GALILEAN STUDIES AND SIMILITUDE THEORY

As indicated in the abstract of this paper, it was the book of Timoshenko, which stimulated Lobo Carneiro to perform an investigation about the contribution of Galileo to strength of materials. Encouraged by the first contact with the Galileo's works he stayed some period in Florence at Museum of History of Science. His main concern obviously was the "Discorsi e dimostrazioni matematiche intorno a due nuove scienze" (Galileo, 1638). Adriano Carugo and Ludovico Geymonat reorganized the main work of Galileo in 1958 by adding some remarks and very useful comments for historians of sciences. The two new sciences mentioned in its title refer to study of motion and to strength of materials.

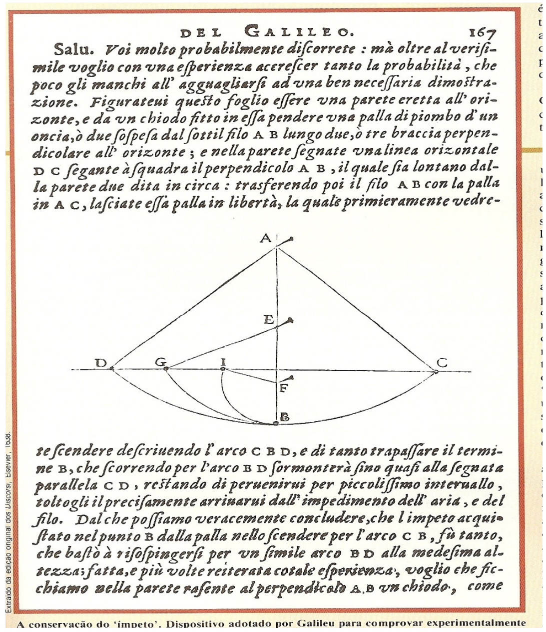

DISCORSI
E
DIMOSTRAZIONI
MATEMATICHE,
intorno à due nuoue ſcienze
Attenenti alla
MECANICA & i MOVIMENTI LOCALI,
del Signor
GALILEO GALILEI LINCEO,
Filoſofo e Matematico primario del Sereniſſimo
Grand Duca di Toſcana.
Con vna Appendice del centro di grauità d'alcuni Solidi.

IN LEIDA,
Appreſſo gli Elſevirii. M. D. C. XXXVIII.

Figure 3. Galileo's masterpiece.

Initially, Lobo Carneiro tried to develop and to investigate the clue left by Timoshenko but he realized as the investigation is going on that Galileo was not only the founder of strength of materials but the first to formulate the similitude theory which supports the scientific construction of models for analysis of structures in general and machinery models in particular.

In "Giornata prima" of the Discorsi Galileo states by means of Salviati: "With respect to the time proportion of oscillation of masses suspended by strings of different lengths, these times perform a ratio in the same proportion as the square roots of that string lengths, what means that the lengths perform a ratio as the times squared… consequently the string lengths are in an inverse proportion of the number of oscillations performed in the same time squared".



DEL GALILEO. 167

Salu. *Voi molto probabilmente diſcorrete : mà oltre al veriſimile voglio con vna eſperienza acereſcer tanto la probabilità, che poco gli manchi all' agguagliarſi ad vna ben neceſſaria dimoſtrazione. Figurateui queſto foglio eſſere vna parete eretta all' orizonte, e da vn chiodo fitto in eſſa pendere vna palla di piombo d' un oncia, ò due ſoſpeſa dal ſottil filo* A B *lungo due, ò tre braccia perpendicolare all' orizonte; e nella parete ſegnate vna linea orizontale* D C *ſegante à ſquadra il perpendicolo* A B*, il quale ſia lontano dalla parete due dita in circa : trasferendo poi il filo* A B *con la palla in* A C*, laſciate eſſa palla in libertà, la quale primieramente vedrete ſcendere deſcriuendo l' arco* C B D*, e di tanto trapaſſare il termine* B*, che ſcorrendo per l'arco* B D *ſormonterà ſino quaſi alla ſegnata parallela* C D*, reſtando di peruenirui per piccoliſſimo interuallo, toltogli il preciſamente arriuarui dall' impedimento dell' aria, e del filo. Dal che poſſiamo veracemente concludere, che l impeto acquiſtato nel punto* B *dalla palla nello ſcendere per l' arco* C B*, fù tanto, che baſtò à riſoſpingerſi per vn ſimile arco* B D *alla medeſima altezza; fatta, e più volte reiterata cotale eſperienza, voglio che ficchiamo nella parete raſente al perpendicolo* A, B *vn chiodo, come*

Figure 4. A page of Galileo's Discorsi showing pendulum oscillations

This dialog between Salviati and Sagredo is quoted by Lobo Carneiro to confirm the pioneering work of Galileo in the similitude theory and thus it permits to derive parameters related to the dynamic behavior of prototypes. The example given by Galileo for the direct determination of the length of the prototype-pendulum would be too hard because the superior extremity of the string is fixed in an unknown height. By using a scale model the determination of this length is made by an indirect way. This is exactly the philosophy of the application of reduced models in the experimental investigations.

Galileo discovered the laws governing the pendulum oscillations for small displacements: these oscillations are approximately isochrones. This implies that the period of oscillations is not dependent of its mass being proportional to square roots of lengths. Galileo achieved these laws by means of experimentation. However, despite the efforts to demonstrate theoretically these laws he failed because the lack of available mathematical tools.

Starting with the laws of falling bodies along inclined planes he demonstrated the equivalence of descending times along the cords that passed through the lowest point reached by the mass and any point belonging to the circle which center is the suspension point having radius equal to the length. This time is equal to the free fall along the vertical diameter, the biggest cord. Yet, he demonstrated that the time to fall completely along the arc length passing through the extreme position and the lowest position is lesser than the falling along the associated cord. The pendulum period is slightly lesser than the time of free fall along a displacement twice times its length. Later on, Newton (1642-1727) and Jacques Bernoulli (1654-1705) demonstrated that the time of fall would be lesser along the cycloid: the brachistocron instead of a circle as Galileo supposed. It is worth to mention that Christian Huygens (1629-1695) demonstrated that the oscillations of a pendulum are not isochrones for large displacements. A large displacement in systems like a pendulum implies to consider non-linear behavior and a more sophisticated mathematical analysis (Drake, 1978).

Using only proportions instead of absolute values, Galileo never found the factor of proportionality of his law which related the period T to the square root of the pendulum length L neither the gravity acceleration g, which is the constant of proportionality relating the double space S of free fall to the squared time of it. Nowadays, we know these proportionality factors. For the free fall we have:

$S= ½ gt^2$ and $V= gt = \sqrt{2gs}$; for the pendulum, $T= 2\pi \sqrt{(L/g)}$ (Carneiro, 1965).

Stillman Drake, investigating Galileo's archives at National Library in Florence, discovered that Galileo made an experimental evaluation with good accuracy, of the relationship between one quarter of the period oscillation, which is the time to fall along the arc length passing through the extreme position to the lowest point, and the time of vertical fall along the pendulum length. This relation is $\pi/2\sqrt{2}$, called by Drake "Galileo's constant".

Another interesting idea of Galileo in Discorsi is known as "the weakness of giants". It means that when we construct a small model in order to pass to the prototype we have to take into account that weights grow up with the length to the cubic power while the strength increases with the square power, such that a giant is relatively weaker than a small one. Lobo Carneiro concluded by reading the available manuscripts that, in fact Galileo was the first to explain that geometric similitude is not enough to guarantee a proportional strength to prototype. In the theory of models not only the geometric proportionality is taken into account but also other necessary conditions are established as the properties of materials and the environmental relations. The discussions about the "weakness of giants", that we can find out in Discorsi conducted Lobo Carneiro to another original conclusion: Galileo constructed the first dimensional product or a π number, a non-dimensional parameter which value must be constant in order to maintain the physical similitude.

As we know, the theory of strength of materials is presented by Galileo at beginning of "Giornata prima", and along the "Giornata seconda", which title is: "Scienza nuova prima, intorno alla resistenza de i corpi solidi all'essere spezzati". The second science, the science of motion is presented in "Giornata terza" and "Giornata Quarta": "scienza nuova altra, de i movimenti localli". Galileo was conducted to investigate the strength of materials of solid bodies by the problem of violation of physical similitude.

He achieved to this conclusion by means of empirical considerations that appear when we compare structures with geometric similitude built with the same material but with different scale's factors. The resistance does not follow the same proportion. The accumulated empirical knowledge in Galileo's time already indicated this fact. It would be corroborated by several observations. Animals and structures of big sizes are weaker than that of small sizes geometrically equivalent.

Galileo searched for a theory to explain this phenomenon. He did not agree that worst performance of big structures occurred only because the heterogeneity of materials or manufacturing defects. He believed and established in his new theory that rupture of solid bodies appears by the violation of physical similitude. In other words, the "weakness of giants" is due to the fact that increasing the dimensions of a body maintaining the geometric proportion its weight increases by a factor greater than the capacity to resist to additional forces.

It is useful in dimensional analysis to identify the non-dimensional numbers with names of known scientists. We have the numbers of Froude, Reynolds, Weber, Cauchy, Strouhal, etc. Thus, the non-dimensional parameter constructed by Galileo according to Lobo Carneiro is: the Galileo number, the ratio between the product of specific weight by some characteristic length divided by the strength of material.

As a general evaluation of his Galileo's studies Lobo Carneiro said: "I tried in my investigations on Galileo's work to use primary sources instead of indirect readings because frequently the commentators of Galileo based their analysis according to philosophical and ideological tendencies. It is common to consider Galileo as empiricist or Platonist. In fact Galileo was not neither empiricist nor Platonist. The scientific researches performed by Galileo were ever an appropriate combination of observation and experimentation with mathematics as a tool of deductive logics".

The last contribution of Lobo Carneiro to the similitude theory was as historian of sciences. It was the fact that Edgar Buckingham is not the first to contribute to the famous theorem of Π numbers. As Lobo Carneiro showed, in 1914 a paper "On physically similar systems: Illustrations of the use of dimensional equations", was published in Physical Review by Buckingham, but he found a paper of a French engineer, Alfred Vaschy, published in 1892: "Sur les lois de la similitude physique", where the theorem of Buckingham was enunciated and demonstrated.

4. CONTRIBUTION TO DIMENSIONAL ANALYSIS AND THEORY OF MODELS

Let's see in a concise way the book of Lobo Carneiro about similitude theory. Its title is: "Análise Dimensional e Teoria da Semelhança e dos Modelos Físicos" (Dimensional Analysis and Theory of Similitude and Physical Models) edited in Brazil in 1992. The author studied in depth several physical phenomena as result of previous investigations along many years, as we have seen starting by Galileo. The book is divided in twelve chapters as follows:

Chapter 1: Fundamental and secondary quantities. Systems of measurements unities.

Chapter 2: Introduction to the theory of dimensional homogeneity. Dimensional matrix.

Chapter 3: Principle of dimensional homogeneity. Theorem of π or Vaschy-Buckingham.

Chapter 4: Numbers π Method to obtain complete sets of numbers π independent.

Chapter 5: Static and Dynamics problems of mechanics of deformable bodies.

Chapter 6: Fluid-rigid bodies interaction in relative steady state or periodic motions.

Chapter 7: Problems of fluid mechanics. Fluid flow in closed tubes and in free surfaces. Newtonian and Non-newtonian fluids. Fluid in porous media.

Chapter 8: Problems of conduction and heat transfer. Forced and natural convection.

Chapter 9: Physical similitude. Incomplete similitude. Scale effect. Method of Huntley.

Chapter 10: Conditions for the physical similitude in the interaction of fluid- flexible structures. Models of offshore structures.

Chapter 11: Dimensional analysis applications to electromagnetic and solid state physics.

Chapter 12: Similitude conditions in biology. Time scale.

Figure 5. Book: Dimensional Analysis and Theory of Similitude and Physical Models.

In the Introduction and Chapter 1, the fundamental concepts and basic ideas are presented as dimensional homogeneity, physical similitude and definition of model. Systems of unities mainly the SI and technical systems are studied and how physical laws and natural processes can be represented. It is discussed briefly the fundamental principle of dimensional analysis: laws and processes mathematically written do not depend of systems of unities and the equations expressing those laws are the same even if we change the system of unity by changing the magnitude of fundamental unities.

In Chapter 2, general aspects of functional relationships describing laws or physical processes are studied. In this context the dimensional matrix is an important tool because it expresses the representative quantities by a matrix where lines represent fundamental quantities associated to the problem and each column represents one parameter. Matrix elements are parameters dimensions related to each fundamental quantity. Some applications are shown as the problem of fluid flows in closed tubes. Linear algebra is applied to change the base of any system by constructing algorithms with this purpose.

In Chapter 3, the author works with the concept of dimensional homogeneity and finally the famous π theorem or Vaschy-Buckingham is presented and demonstrated. The classic definition of Euler (1707-1783) homogeneity is revisited and generalized. It is also carefully explained the meaning of π theorem. In this context the author also shows that after 22 years of Vaschy's article in 1914 appeared the famous Buckingham paper "On systems physically similar: about the use of dimensional equations"(Buckingham, 1915). He attributed the name of Π theorem by choosing a greek letter to indicate the latin letter P expressing "product". He also introduced the ratio nowadays known as shape factor.

In Chapter 4, it is studied how to organize a set of parameters to describe the problem under consideration and what quantities indeed represent it. Some rules to replace one set of Π numbers to other equivalent and how to obtain a complete set of them are presented and discussed by the author. We can see that algebra of matrices is a fundamental tool in this context. Finally an attempt is made to interpret physically Π numbers.

In Chapter 5, Lobo Carneiro proposed in item 5.7 the dimensional number identified as Galileo's number. It is mainly addressed to static problems of deformable bodies under gravity. The number, a dimensional one evaluates the ratio between the gravitational forces and the strength of material. The author states: "Galileo has demonstrated that if all the dimensions of the body will be multiplied by a number, if the geometric similitude is preserved, the weight of the body increases with the cubic power of the geometric scale while the strength increases with the second power. Hence, a greater body has less capacity and less resistance to applied forces, relatively to its weight than the small body and thus exists a limit in the size and the body under consideration resists only to its weight". The same consideration expressed above in his book was already postulated in 1965.

In Chapter 6, fluid-structure interaction is studied for rigid and flexible bodies. The first case, relative to rigid motions, steady or periodic motions inside an infinite fluid are studied. This case includes displacements of ship in fluid in equilibrium or a flow around a fixed body. The second case, for flexible bodies, wave motions acting on fixed structures, as offshore structures will be studied later on. This chapter and the next are addressed to the main concern of the author: offshore structures. For periodic motions as mentioned above, when rigid bodies are inside an infinite fluid around it, the study conducts to dimensionless numbers of Keulegan-Carpenter, Froude and Reynolds.

In Chapter 7, the study is mainly concerned with fluid mechanics. The properties of fluids, Newtonians or non-newtonians are discussed. The dimensional analysis is applied to flow inside closed tubes with any kind of cross section, circular or non-circular types. For non-newtonians fluids the author introduces a kind of constitutive equation compatible to liquid like oil because the concern is to apply the study to offshore structures. The study presented is generalized fluids with a viscosity law not time-dependent. This chapter is finalized with an interesting study of flow through a porous media.

In Chapter 8, the problems of heat transfer are analyzed using the famous book (Fourier, 1822) . In his book, the concept of dimensions of a physical quantity is presented giving more clarity and more simplicity to dimensional analysis. Fourier is concerned in his book with heat exchange of a body initially heated and suddenly transferred to a cold environment. Immediately, heat conduction occurs from inside to outside the body and a heat transfer to environment. Dimensional analysis conducts the study to Biot and Fourier numbers. The problem proposed by Fourier is analyzed thoroughly including natural and forced convection.

In Chapter 9, the author in a more depth than in the previous chapters revisits physical similitude. In some problems, frequently a complete physical similitude is not possible. This occurs, for instance in structures where the theory of plane sections fails. When the similitude is not complete, deviations and errors appear and we refer to scale effects. This discussion conducts to construction of models with distortions, i.e. the adoption of geometric different scales. The author introduces a new theory to be applied to any study of models with distortions: Hurtley's theory. The applications presented as examples suggest how to construct models for dams and ground foundation.

In Chapter 10, some aspects and some problems discussed in Chapter 5 are developed regarding problems presented by offshore structures a kind of problem that drew the attention of Lobo Carneiro for many years. One of them is to establish the condition for the similitude between the model and the prototype. In the case of offshore structures this problem increased by the difficulty to use another fluid instead of water for both, model and prototype. This difficulty conducts the investigations to the use of a model in which the geometric proportion is broken. In other words it is necessary to introduce a distortion in the model.

In Chapter 11, dimensional analysis is applied to problems of electromagnetism and to solid-state physics. Dimensions of electrical and magnetic quantities as well as the universal physical constants are obtained by five laws and by Maxwell's assumption on the equivalence between the displacement current and conduction current. As we know, these laws and assumption is the physical basis of electromagnetic theory. The above-mentioned laws are the Coulomb (1736-1806) law, Biot-Savart-Laplace law, Ampere (1775-1836) law, Ohm

(1787-1854) law and Faraday (1791-1867) law. This chapter develops its dimensional analysis with these elements and applies to physical models for many examples. With respect to solid-state physics, the author follows the steps and clues left by Einstein's articles published in 1911 in "Annalen der physik". In this publication Einstein quoted: "By dimensional considerations it is possible to find out approximately general functional relationships among physical quantities if all of these quantities are considered". The analysis performed by Lobo Carneiro follows this track.

The Galilean studies inspired Lobo Carneiro to go in the direction of biology in Chapter 12. Again the problem of "weakness of giants" is the starting point. He remembers that Galileo proposed two solutions for that problem. For a giant to maintain the same strength equivalent to the common man he would change the material of his bones by another harder or to reduce the specific weight of all materials of the body. But Galileo also proposed other solution as Lobo Carneiro remarks, to break the proportionality and increase not proportionally the thickness of bones such that the giant looks like a monster. This is expressed geometrically by a figure of a big bone compared with a small one.

The big bone has a length of three times the small. However the transversal scale is nine times.

With the above considerations, the author began to study some biologic processes as animal metabolism, the exchanging of heat involved in that, which is a new and modern incursion in unexplored branches of engineering. These studies finalize the interesting book of Lobo Carneiro.

His book had a good reception in scientific community and has also a good circulation in the Schools of engineering in Brazil as a textbook in many post-graduated courses. It is worth to remember that Lobo Carneiro's book appeared as result of many years of courses on dimensional analysis in COPPE/UFRJ with guidance of several PhD thesis applying tools developed by him.

5. DIMENSIONAL ANALYSIS AND MACHINE DESIGN

Dimensional analysis arose from an attempt to extend to physics the Greek concepts of geometrical similarity, ratio, and proportion. As we have seen previously, dimensional analysis was first applied by Galileo to predicted the strength of beams of given material as a function of their linear dimensions. He assumed that it is intuitive and obvious that, for any given material, failure of a beam occurred when the force-per-unit-area, the stress, exceeded a certain maximum. He concluded that the safe load per-unit-volume was inversely proportional to the length and in this way he anticipated various other useful results.

Other applications appear in Newton´s "Principia", Vol. 2, and Section 7 (Newton, 1687). However, it was Fourier who first stated that there are certain "fundamental units", in terms of which every physical quantity has certain "dimensions", to be written as experiments. More recently, Lord Rayleigh showed the generality of this procedure as a general method.

Dimensional analysis is based in the property that physical laws are unit-free and this fact was treated mathematically. Thus, we can interpret the plausible principle that all units of measurements are valid and imply that all such units must given rise to the same universal physical laws.

From a historical point of view there is a narrow relation between dimensional analysis and machine design. It is well known that Francesco di Giorgio (1539-1501) identified the mechanical drawing as a tool for intellectual expression and as a mean to affirm the professional emancipation of technicians and engineers, who until that time had been considered artisans. But he also affirmed the irreplaceable role of the three-dimensional model during the design phases of a machine. In his "Treatise on Architecture" he wrote: "It is difficult to show everything in a drawing because so many components are interrupted and on top of one another that to draw them all is impossible, and so, it is necessary to make a model of practically everything".

This limitation indicated by di Giorgio was overcome by Leonardo da Vinci (1452-1519) who, even though used three-dimensional models in various aspects of his research: machines, painting, anatomy, etc. Leonardo appears to have given drawing pre-eminence over models, recognizing is value both in terms of design and as means of expression.

The use of drawings instead of models made the difference between an evolved engineering, where the engineer considered himself to be a mean with a mind in addition to his hands. The machines that Leonardo designed can be studied and presented as three-dimensional reconstructions, even as interactive models, as they are in some museums and exhibitions.

6. SUMMARY OF MAIN HOMMAGES AND PRIZES

1929 – Silva Ramos medal, better student of secondary course in Rezende School.
1934 – Gomes Jardim medal, better student of Polytechnic School of Rio de Janeiro.
1980 – Distinguished researcher of INT (National Institute of Technology).
1981 – Emilio Baumgart prize, IBRACON (Brazilian Institute of Concrete).
1983 – Distinguished member of RILEM (Réunion Internationale des Laboratoires d´Éssais et des Récherches sur les Matériaux et les Constructions).
1984 – Bernardo A. Houssay interamerican prize from OEA (American States Organization).
1987 – "Honoris Causa" doctor of UFRJ (Federal University of Rio de Janeiro).
1989 – Alvaro Alberto admiral prize of CNPq (National Development Council of Science and Technology).
1994 – Science and Technology ministery medal.
1994 – "Honoris Causa" doctor of UFBA (Federal University of Bahia).
1998 – Eminent engineer of the year, Polytechnic School of UFRJ.
1999 – Titular member of Brazilian Academy of Sciences.
1999 – City of Rio de Janeiro prize of Science and Technology.
1999 – Special homage from XXIX Southamerican journey of structural engineering.
2000 – Carlos Chagas Filho medal, FAPERJ (Foundation for Support and Development of Research of Rio de Janeiro).
2001 – Distinguished professional of 2001, CREA (Regional Council of Engineering and Architecture).
2001 – CAPES medal.
2002 – CONFEA medal.
2003 – Fernando Luiz Lobo Barboza Carneiro prize created by IBRACON.
2004 – Lobo Carneiro space created in COPPE/UFRJ for scientific diffusion.
2004 – Distinguished by ABNT with the title of "genious of engineering".


Réunion Internationale des Laboratoires d' Essais et de Recherches sur les Matériaux et les Constructions

The General Council of RILEM,
on behalf of the RILEM membership,
elects on this, the 2nd day of September, 1983
Fernando Luis Lobo B. Carneiro
as an
Honorary Member
in recognition of his invaluable services to RILEM

James R. Wright
President

Secretary General
Paris, France

Figure 6. Title of Honorary Member of RILEM


Associação Brasileira de Cimento Portland

Instituto Nacional de Tecnologia

Ao realizar-se o 100.º Curso Intensivo de Tecnologia do Concreto e na passagem do 60.º aniversário do INT, a Associação Brasileira de Cimento Portland e o Instituto Nacional de Tecnologia conferem o presente Diploma a

Fernando Luiz Lobo Carneiro

por sua participação no processo de aprimoramento da tecnologia do cimento e do concreto no País.

Rio de Janeiro/RJ, 6 de agosto de 1982

Secretário Executivo da ABCP

Diretor Geral do INT

Figura 7. Lobo Carneiro, distinguished researcher of INT (1982)

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