

DINEST AN EDUCATIONAL SOFTWARE FOR STRUCTURAL DYNAMIC DESIGN AND BEHAVIOUR

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Abstract — *The significant development of constructive processes allied to the conception of daring architectural designs led to creation of very slender structures. These aspects induced civil and mechanical engineers to take extra care with the possible occurrence of vibration problems arising from various structures when subjected to dynamical load actions. These dynamical forces are frequently found in wind and wave loads acting on building structures and human rhythmic activities that can occur in sports pavilions and dance halls. On the other hand, it crystal clear that undergraduate engineering students present a great difficulty in understanding the physical phenomena associated with the dynamical behaviour of structures. This was the main motivation for educational software described in this paper. This graphical educational tool helps the undergraduate engineering students to visualize, understand and learn the evaluation process associated with the dynamical behaviour of structures with the aid of simple practical examples. This paper briefly presents the development of the referred educational software, denominated DINEST.*

Index Terms — *Structural dynamics, Educational software, Engineering courses, Engineering education.*

INTRODUCTION

The significant development of constructive processes allied to the conception of daring architectural designs led to creation of very slender structures.

These aspects induced civil and mechanical engineers, responsible for structural design, to take extra care with the possible occurrence of vibration problems arising from various structures when subjected to dynamical load actions.

The dynamical forces are frequently found in: engine foundations, wind and wave loads acting on building structures. Some other examples are associated with earthquakes, explosions, impact of moving objects and human rhythmic activities that can occur in sports pavilions, gymnasiums and dance halls.

In all those cases the equilibrium of the structural systems is only made considering the inertia forces. All the above-mentioned situations confirmed the importance

of a proper dynamical analysis in current day-to-day engineering practice.

The main objective of this paper is to present the development of an engineering educational software that is able to consider the dynamical load actions over civil and/or mechanical structural systems.

The educational program, *DINEST*, developed in the windows environment, was conceived to help undergraduate engineering students to clearly visualize and understand the structure dynamical response.

DYNAMICAL LOAD ASSESSMENT IN ENGINEERING DESIGNS

The increasing competitive trends of the world market have been making structural engineers to produce design focused to the minimum material and labour consumption not disregarding the required construction speed.

On the other hand, an increase of problems related to unwanted structural vibrations in structures subjected to dynamical loads is being clearly felt.

This growth is associated to the fact that the great majority of structural engineers do not know how to evaluate if these problems can compromise the structural performance only using the simple elastic static analysis procedures currently adopted in day-to-day practice.

If this is the only used procedure, when the structure is subjected to dynamical loads excessive vibrations, compromising human comfort conditions and even jeopardising the structural system integrity could occur.

THE DINEST PROGRAM

The development of a graphical educational software to motivate undergraduate engineering students to understand the structure dynamical response led to adoption of the DELPHI programming language [1].

The program *DINEST* (Structural Dynamics) architecture was based on the use of several independent windows screens based on the windows environment. The students use these windows to input data by filling block spaces or selecting buttons.

According to the sequential use of the *DINEST* program the undergraduate engineering students are capable to perform free and forced vibration analysis of numerous simple didactic structural systems [2]-[4].

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The *DINEST* program was conceived to be a useful complementary tool for the regular undergraduate courses of the Faculty of Engineering of the State University of Rio de Janeiro, FEN/UERJ (Structural Dynamics, Mechanical Vibrations, Special Topics on Structural Problems).

Initially this paper will present examples associated with one degree of freedom (S1GL). The *DINEST* program is able to perform a free vibration analysis by evaluating the structure natural vibration frequencies or in a forced vibration analysis, the system time versus displacement response. This is performed considering rectangular and harmonic dynamic loads (load and/or pulses) [2]-[4].

The educational software enables the users to define new or adopt default values for the damping parameters. Another interesting feature is that the program allows the

user to access and change the system physical properties like: mass, damping and stiffness.

The first window of the *DINEST* program introduces a menu with the “file” and “help” options. The “file” option enable the user to begin a new analysis, recover data stores from a previous analysis, save the current analysis and to exit the program. The “help” option is allows the user to access a series of information regarding the dynamical analysis as well as a detailed description of the software main features, as illustrated in Figure 1.

The dynamical structural analysis should be preceded by the required dynamical system characteristics, defined by the users from the “stiffness” and “damping” options. The user has at this point an option of accessing a “help” command that will briefly explain the physical concepts associated with structural stiffness and damping, as shown in Figures 2 and 3.



FIGURE. 1
OPENING WINDOW OF THE *DINEST* PROGRAM.

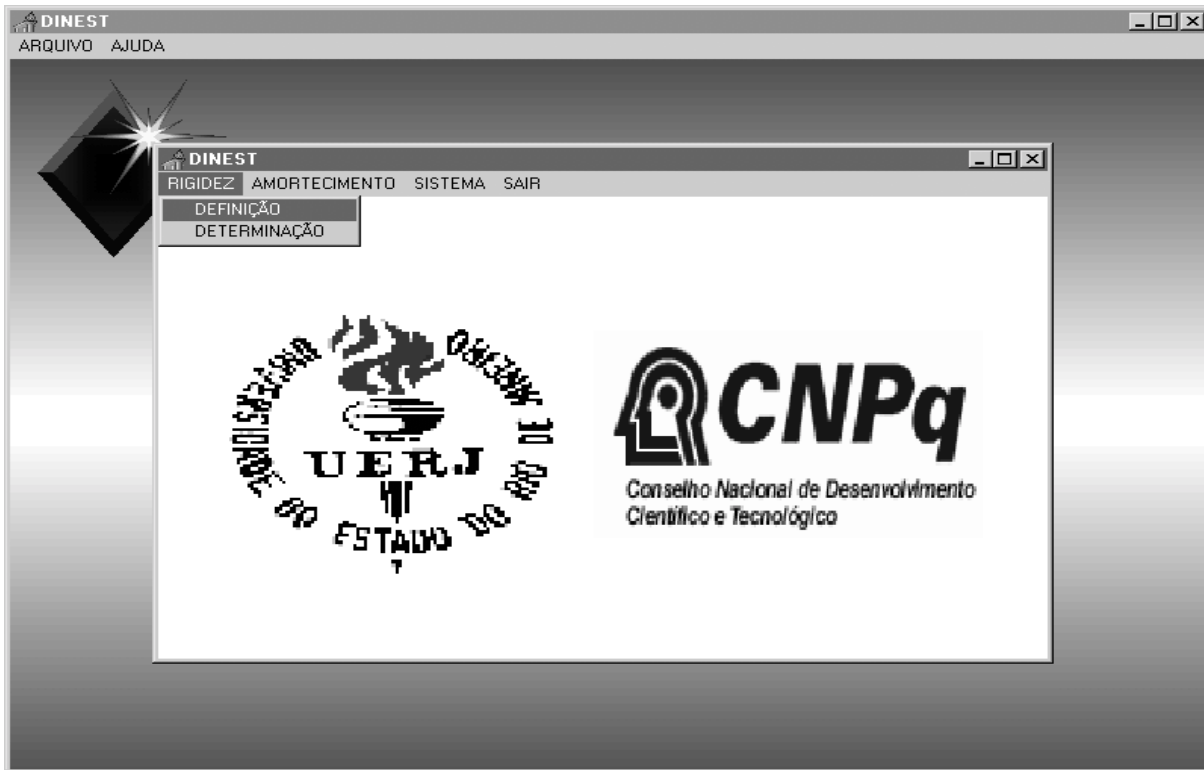


FIGURE. 2

DEFINITION OF THE STIFFNESS AND DAMPING COEFFICIENTS BY THE USER.

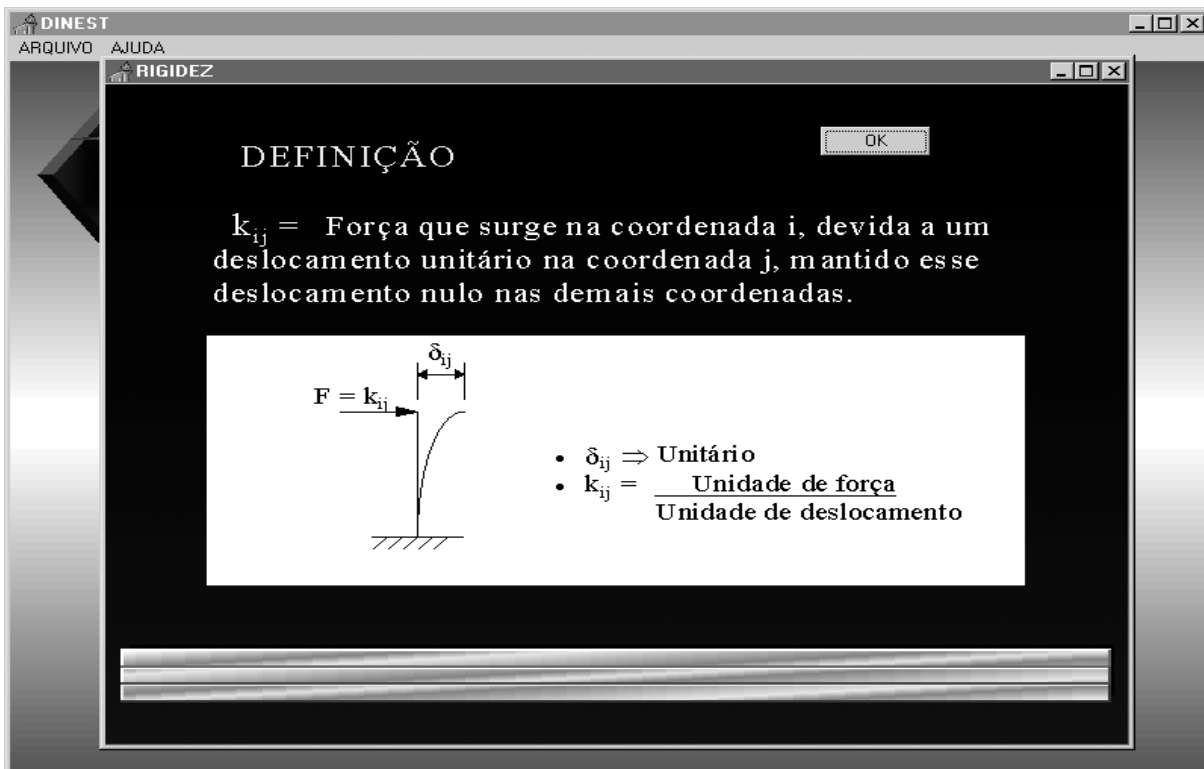


FIGURE. 3

THEORETICAL DEFINITION OF THE STIFFNESS COEFFICIENT.

With these results in hand the user should, based on the “system” option, choose the adopted structural model, for instance a one degree of freedom model S1GL, in which the dynamical analysis will be performed, as shown in Figure 4.

By selecting a new model (simple pendulum, rigid beam, mass-spring-damping and torsion pendulum) [4], the user begins to use a distinct interactive data input window associated to each individual structural system.

Every data input window generated by the *DINEST* program based on the “system” option allows the system to obtain from the users the required information according to the used dynamical model.

These numerical values should be positioned/selected in their respective boxes or buttons, as depicted in Figures 5 and 6.

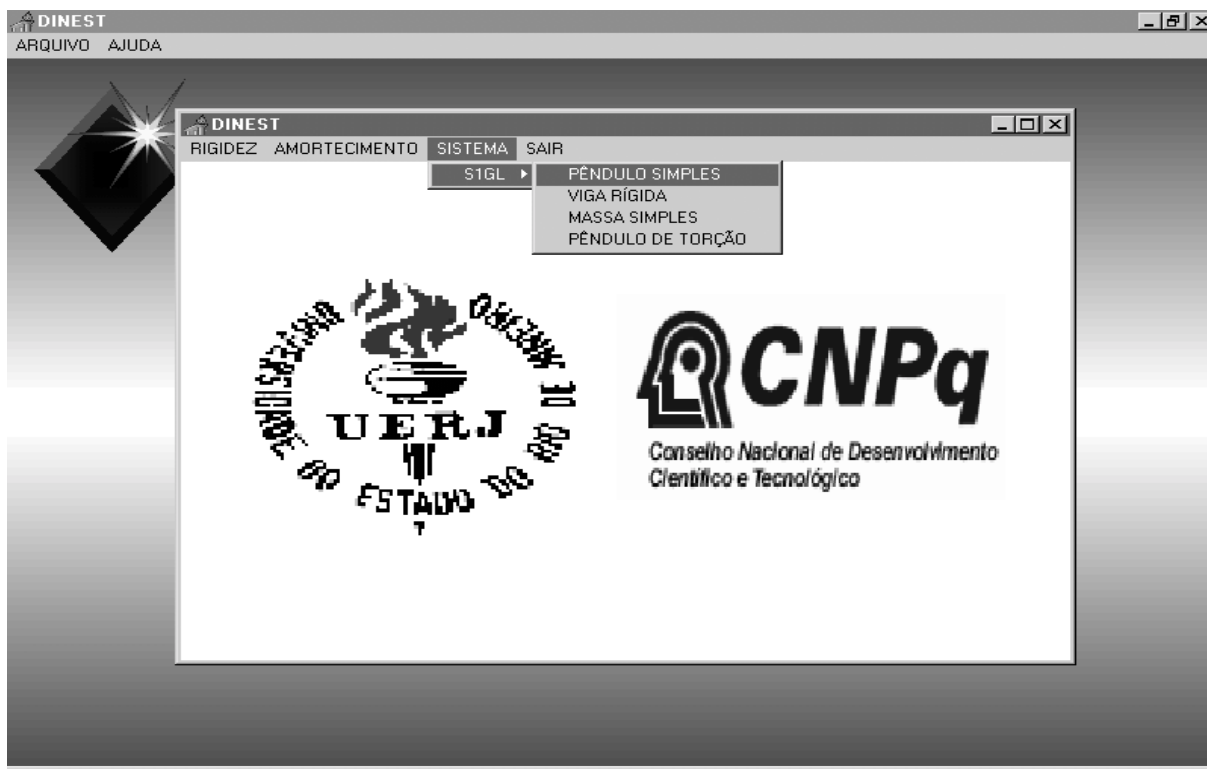


FIGURE. 4
DIALOG WINDOW FOR THE SELECTION OF A STRUCTURAL MODEL.

The model (simple pendulum, rigid beam, mass-spring-damping and torsion pendulum) [4], windows “theory” buttons allows the access to the technical information associated to each structural model according to the user specific needs, as illustrated in Figures 5 and 6.

When the option “excitation” is selected the user can define in the structure dynamical (load or pulse) actions will be rectangular and/or harmonic. When the “calculate” button is selected the program evaluates and displays in a separated window the analysis results as presented in Figures 5 and 6.

Finally, the options “save” and exit” are associated to the input and output data storage for the current analysis as well as to the return to the initial program window, in which the users define a new structure analysis, as depicted in Figures 5 and 6.

Due to this paper length limitations a step-by-step example of the use of the *DINEST* program will be

presented. This example, typical of an engineering undergraduate course, is related to a mass-spring-damping one degree of freedom structural system (S1GL). The Figure 7 presents the data inputted by the user as well as the system output results.

FUTURE DEVELOPMENTS

The first version of the *DINEST* program still has some limitations. The first is related to the maximum number of degrees of freedom. At the present stage the program only evaluates one degree of freedom structural system (S1GL). Structural systems presenting more degrees of freedom (SVGL) are currently being implemented.

Another aim is to include: new structural systems like portal frames and new structure dynamical triangular and trapezoidal (load and/or pulse) to be used in a forced vibration analysis.

Finally new dialog windows should be implemented presenting the users with the structure time response in terms of displacements, forces and moments as well as the

response spectra for a determined dynamical analysis according to previously defined frequency bands.

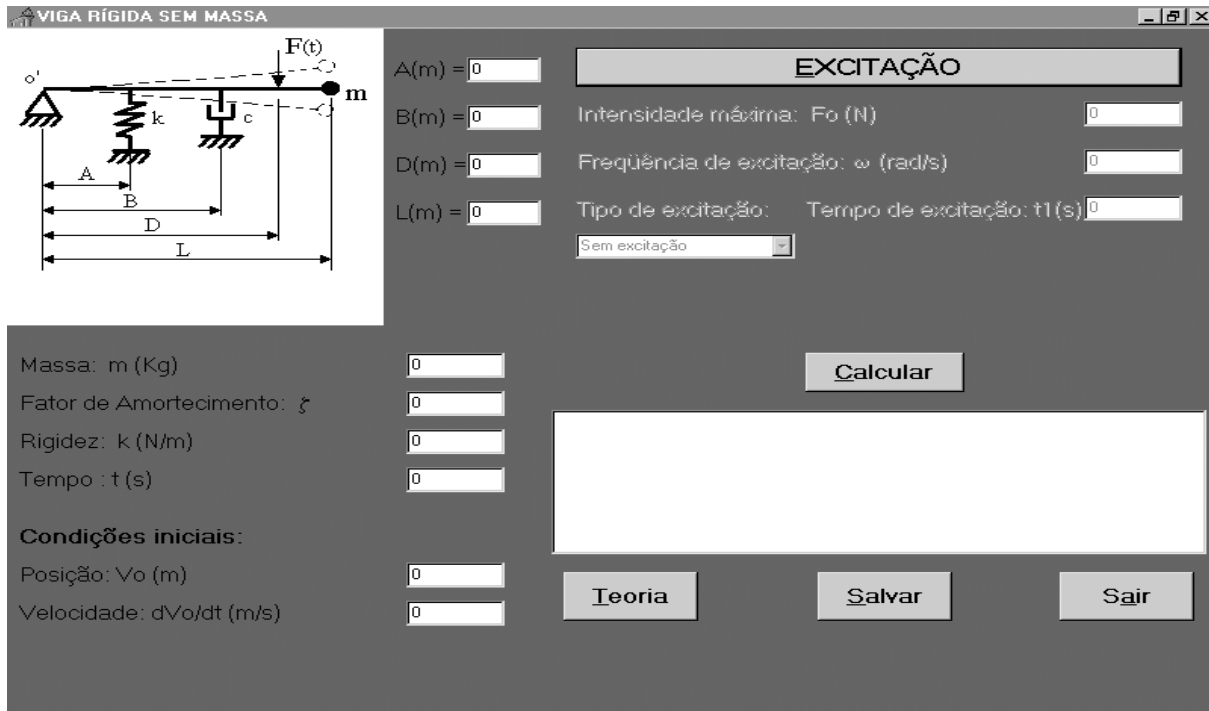


FIGURE. 5
RIGID BEAM MODEL.

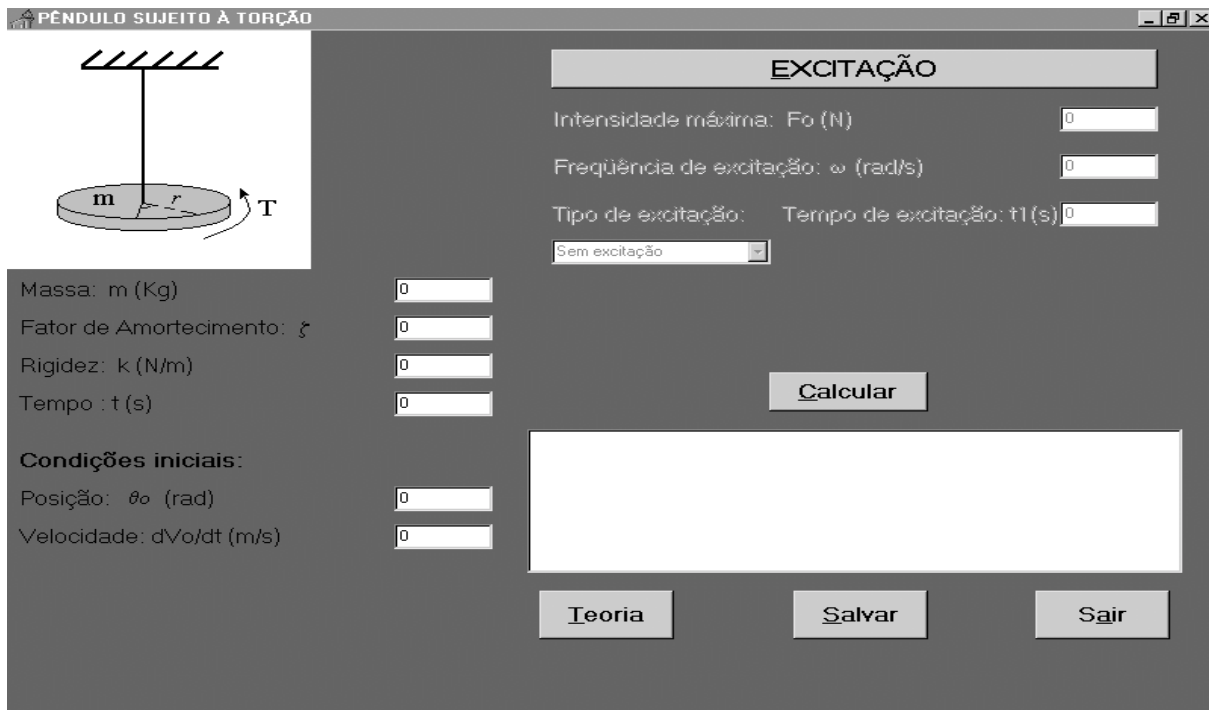


FIGURE. 6
TORSION PENDULUM MODEL.

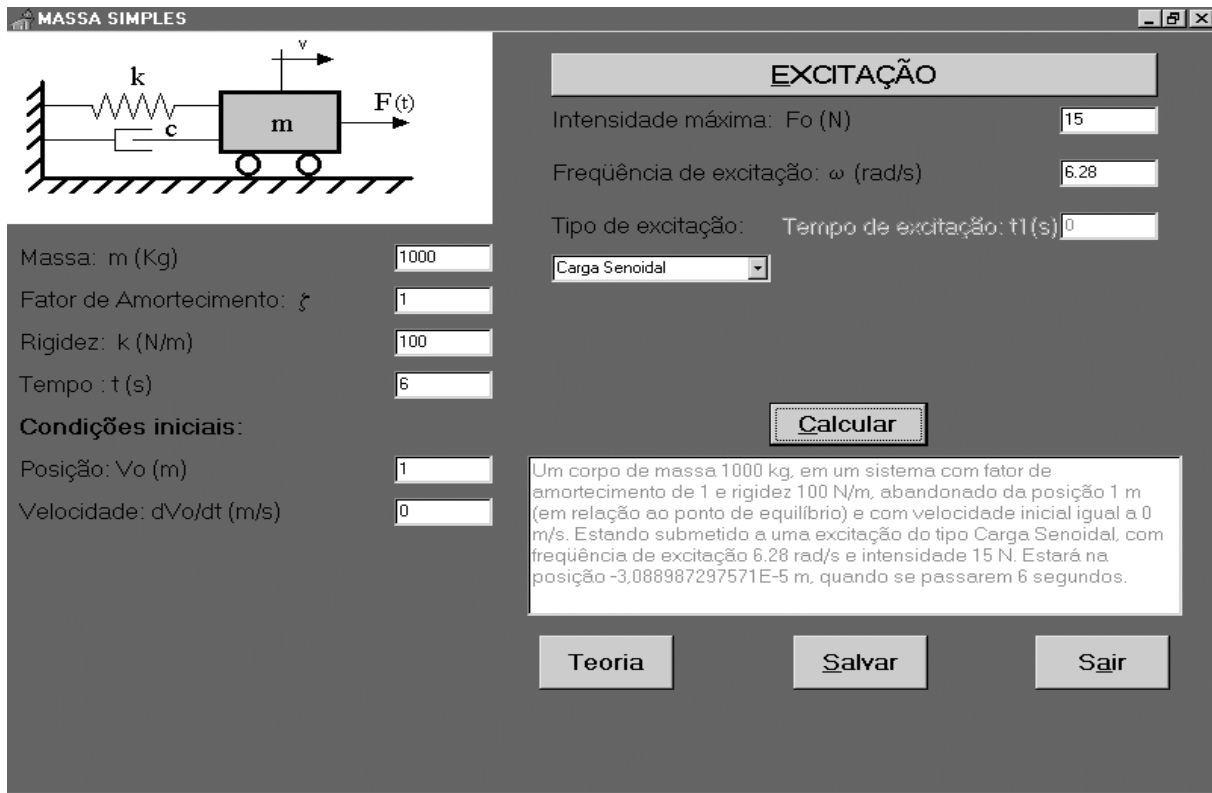


FIGURE. 7

DIALOG WINDOW WITH THE RESULTS FOR A SPECIFIC DYNAMICAL ANALYSIS.

FINAL CONSIDERATIONS

The development of this research project contributed to the implementation and use of a graphical educational tool, the *DINEST* program that evaluates the structural systems response when subjected to dynamical loads.

The software described in the present paper was implemented on the Computational Laboratories of the State University of Rio de Janeiro, FEN/UERJ.

These graphical educational tools help the students to visualize, understand and learn, the evaluation process associated with the dynamical behaviour of structures with the aid of simple practical examples. On the other hand, this paper clearly demonstrates the need to introduce structural dynamic basic concepts to engineering undergraduate students.

This initiative is currently motivating the development of new user-friendly engineering educational software on the Computational Laboratories of the State University of Rio de Janeiro, FEN/UERJ. These educational computer programs surely contribute to a more efficient engineering learning.

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