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AERONAUTICAL AND MECHANICAL ENGINEERING
A VIRTUAL LABORATORY FOR EDUCATION BASED ON REAL
TIME EXPERIMENTS**

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Abstract

Vibration experimental courses in engineering education usually require students to follow a “standard procedure.” It is expected from the student to learn the underlying theories through manipulating the equipment, observing the phenomena of vibration and analyzing the data recorded in the laboratory. However, the procedures are complicated and it requires number of trail to make that experiment success. Three steps were defined in the development process: (1) defining the experiment theory and procedure, (2) building a two-dimensional (2D) virtual reality model, (3) adding physics rules to the virtual world. Technical teaching often requires the use of expensive laboratory equipment which are frequently beyond the reach of many students. Students are also required to go to laboratories, which offer the appropriate facilities, according to a strict timetable. For these reasons, the need of alternative methods arises for teaching such as virtual laboratories. In this article we present the virtual laboratory that is being applied to vibration lab.

Keywords: - Vibration experiment; Engineering education; Virtual reality; Virtual equipment.

1. Introduction

Virtual labs use the power of computerized models and simulations and a variety of other instructional technologies to replace face-to-face lab activities. An example of a virtual lab is a collection of digital simulations supported by discussion forums, video demonstrations, hyperlinked glossaries, and e-mail lists organized in a World Wide Web format or on a CD in a shell produced by an authoring language. The most intricate virtual labs include highly interactive virtual reality simulations of lab exercises.

Physical distances and the lack of resources make us unable to perform experiments, especially when they involve sophisticated instruments. Also, good teachers are always a scarce resource. Web-based and video-based courses address the issue of teaching to some extent. Conducting joint experiments by two participating institutions and also sharing costly resources has always been a challenge. With the present day internet and computer technologies the above limitations can no more hamper students and researchers in enhancing their skills and knowledge. Also, in a country such as ours, costly instruments and equipment need to be shared with fellow researchers to the extent possible. Web enabled experiments can be designed for remote operation and viewing so as to enthruse the curiosity and innovation into students. This would help in learning basic and advanced concepts through remote experimentation. Today most equipment has a computer interface for control and data storage. It is possible to design good experiments around some of this equipment which would enhance the learning of a student. Internet-based experimentation further permits use of resources knowledge, software, and data available on the web, apart from encouraging skilful experiments being simultaneously performed at points separated in space.

In the present paper a software package created for educating engineering students based on the principles and performance of various engineering models. The main advantage of this Virtual Lab is its integrated structure covering notation starting from basic theory of component, operation and going all the way to overall performance calculation and observation.

Educational Application of Virtual Reality:-

Recent advance of internet technology greatly extended the ways in which people can access the web. Since a few years ago, the internet could only be used to search for information, or make it available to other users. Today, the internet can also be exploited to conduct actual experiments on physical device available in remote location. Such a technology opens new interesting possibilities for education, training and collaborating investigation. Students are enabling to access resources they do not have and can run experiments much longer than typically allowed in laboratories. They can visit several virtual laboratories available in the world, thus comparing the different approach and solution for the same problem. All the colleges have their own library where students can access to it. But very few students are interested to go to library take books and read because internet provides more information with picture visualisation even in 3D. However, if virtual labs are developed and included then it promotes learning efficiency, enhancing the connection between theory and experiments, saving time and resources and accessing the experiment regardless of location.

Virtual reality lab is a technology that allows the user to interact with an environment that is a simulation of the real world or an imaginary world. Immersion and interaction are the key properties of Virtual lab.

Research goal

The goal of this research is to develop a virtual equipment representing a typical procedural based experiments which aids students in special, for gaining more practical knowledge than theoretical knowledge. This practical knowledge can be gained by number of ways. Here in this paper a new concept has been introduced i.e. virtual lab which focuses on methods of transforming the equipment, experimental procedures and phenomenon related to theories into computer simulated area using Virtual lab.

Actual forced damped and undamped vibration experiments

Actual forced damped and undamped vibration experiments is a basic practical component in dynamics of machine course. In this research a vibration lab experiment is used as a complete case study. In the real laboratory class the experiments that can be performed are:-

1. Forced vibration without damping

2. Forced vibration with damping.

The course is designed to ask the students to preview seven parts of the vibration experiment. 1. Aim of the experiment, 2. apparatus, 3. Theory, 4. Procedure 5. Virtual experimentation 6. Discussion 7. Quiz.

2. Experimental Setup

The setup of vibration lab is shown in figure. There are seven main components used in the course of the experiments and the students need to preview and remember their position before conducting the experiment. These seven components include the rectangular section bar, eccentric mass disc, exciter motor, spring mass system, damper, vibration machine, chart recorder.



Fig 01 :- virtual lab setup

3. Experimental Procedure

The purpose of the experiment of forced vibration without damping is to measure the natural frequency, resonant frequency. And in forced damped vibration we calculate the amplitude for light, medium and heavy damping with respect to speed. However, to get accurate results the experiment should be setup with as few errors as possible.

In this experiment we follow the standard procedure for minimising the mistakes from the user of Virtual lab. These steps are as follows:-

- 1) The vibrating system in this experiment is a beam hinged at one end & supported by a spring at the other end.
- 2) Adjust the screw to which spring is attached with the help of hand wheels such that the beam is in horizontal position.
- 3) There is a rotating disc mounted on the beam which has an eccentric mass. The disc is rotated with the help of variable speed motor.

- 4) At one fixed point on a beam, the amplitude of vibrations can be measured which is proportional to angular amplitude. Hence the amplitude measured with the rulers gives angular amplitude to the some scale.
- 5) Initially, the beam is given a displacement and time required for 10 oscillations is measured from which the natural frequency of vibration is measured.
- 6) The motor is then started and amplitude of vibration is measured for various speeds.
- 7) Take record by changing force frequencies (i.e. at different speed)
- 8) The graph of force frequency (i.e. speed) v_s amplitude is drawn, which shows that the amplitude is max at the natural frequency.
- 9) It is also observed that the frequency of vibration is same as that of force frequency & the force & displacement are in the same direction when the forced frequency is less than natural frequency.

The above steps hold good for vibration without damping. For forced vibration with damping, the damper has to be included. Then take the readings for three various damping positions. They are Light, medium and heavy damping. From this we get the values of light damping amplitude, medium damping amplitude and heavy damping amplitude.



Fig.02:- Procedure for the Forced vibration without damping



Fig. 03:-Procedure for the Forced vibration with damping

Development of Virtual equipment:-

Virtual equipment was developed using the universal vibration lab experiment as the case study. For this, select the specific experiments to be modelled and represent the type of specification and collect the technical details and introduce in the form of web pages using HTML language. A simulation program for estimation of performance operation for each practical is created.

4. Building the 2D Virtual Model:-

The size and relative position of all the components were measured. With this data, added by photograph from front view and by using this experimental setup the exercise are perform in a way i.e a reproduction of actual laboratory test by using virtual laboratory. For this the two practical are already mentioned above.

The virtual laboratory screens are as follows:-

1. Force vibration without damping:-

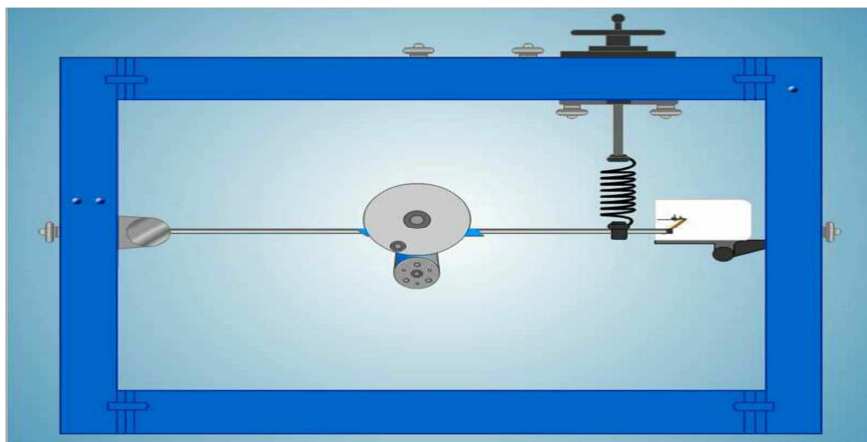


Fig. 04:-Virtual screen of forced vibration without damping.

2. Force vibration with damping:-

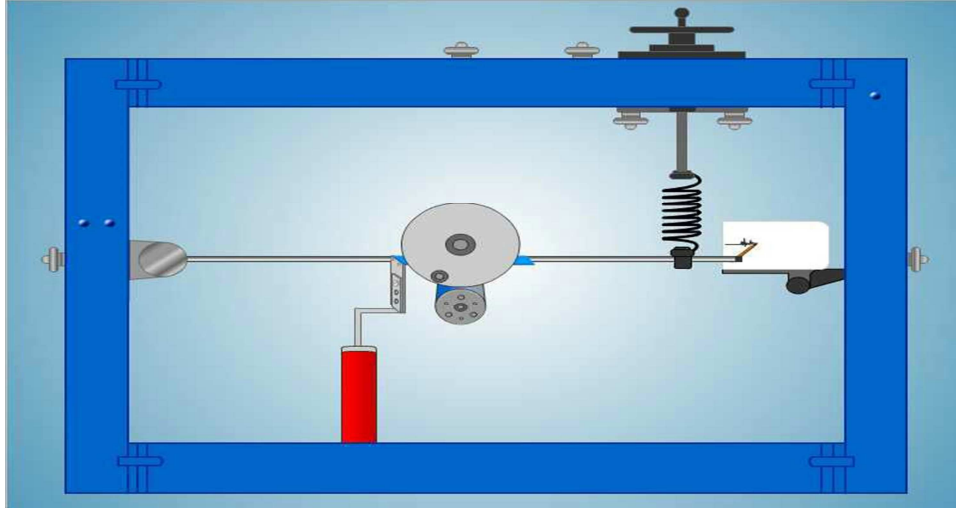


Fig. 05:- Virtual screen of forced vibration with damping.

By using this virtual lab experimentation module we can visualise the practical performance step by step as per the above mentioned experimental procedure. 2D visualisation can be obtained by entering the input values. In the free vibration without damping experiment we have to enter the input value by giving different values of speed and later we obtain the amplitude using virtual experimentation setup. The values of speed and amplitude are substituted in the formula to obtain the resonant frequency and resonance speed.

In the free vibration with damping experiment we have to enter the input values by giving different values of speed and later we obtain the values of light damping amplitude medium damping amplitude and heavy damping amplitude. But the change is that initially arrangement of damping is important are as follows:

1. Close the one hole of damper for light damping
2. Close the two holes of damper for medium damping
3. Close the three holes of damper for heavy damping

5. Conclusion

The achievements of this research includes the redesigning of the actual vibration lab that can be converted into the virtual lab. It is one of the easiest and simplest method to perform the experiments. By this procedure the user is able to understand deeply all the operation of the experiments and it motivates the students and enhances their interest.

This provides the user to interact with real time and verify the time constraints and perform the various control system.

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