Inspirations of "Experimental Engineering"

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Abstract

"Experimental Engineering" is an important course of mechanical engineering in the University of Iowa. The purpose of this course is to help student improve proficiencies to: 1) Design, assembling, and conduct an experiment; 2) Data analysis and results presentation. Authors were inspirited by the experimental setup, teaching material arrangement, and well-defined experiment procedures. It is worth noting that students can design their own project during the experiment design. It is absolutely aligned with our main target of innovation ability training. Therefore, this course is a good example to be followed.

Keywords: Experimental engineering, Experimental teaching, Engineering education, innovation ability, opens experiment

1. Introduction

The Experimental Engineering is compulsory course for senior students of mechanical engineering in the University of Iowa. And it is the most important course in practice in university stage. Through study with the seniors, I had a deeper understanding of mechanical practice teaching in American university. This has great inspiration and help to our current curriculum education reform. And that are same with our target of construction opening laboratory [1,2] and enhancing the innovation capability[3,4].

1.1. Purpose of Course

The purpose of this class is to gain proficiency in designing, assembling, and operating an experiment and then analyzing and presenting the results. This encompasses skills such as understanding control and data acquisition electronics, operation and limitation of sensors, calibration and error analysis, assessing applicability of theory and the impact of secondary experimental variables, and writing and presenting reports and analysis.

Writing reports is a significant component of this course. In the real world, promotion and corporate visibility depend on the impression that reports convey. A well written report is a strong advocate for student's abilities [5].

1.2. Objectives

The overall objectives of the Experimental Engineering course are to develop (1) an awareness and understanding of experimental methods with particular applications to mechanical engineering and (2) ways to communicate effectively the experimental methodology, results, and conclusions. These objectives are accomplished by the following methods [5]:

a) Familiarization and utilization of instrumentation in terms of accuracy, precision, repeatability, response, range of ap-

plication, construction, calibration, and application;
b) Development of experimental objectives, design, and procedures required to perform satisfactorily the experiment;
c) Acquisition, reduction, and analysis of experimental results;
d) Written and oral reports for effective communication of experimental procedure, results, and recommendations to others.

2. Experimental contents

Give me feel the deepest is design of experiment contents, experiment content varied Settings. There are a dozen experiments, but involves heat transfer, aerodynamics, fluid dynamics, and other disciplines. Most experimental apparatus is teacher development and design, each device has only one set, each group chooses three experiments. All experiments list on the Tab.1.

Tab.1：Labs for General Concepts and Measurements Devices [5]

1	Wind Tunnel Testing Principles, and Lift and Drag Measurement
2	Cooling Tower Performance and Sensors for Thermal-Fluid Systems
3	“Isentropic” Blow-down Process and Discharge Coefficient
4	Heat Exchanger Performance Measurement – Shell and Tube vs. Plate
5	Compressed Air Turbine Performance Measurement
6	Boiling Heat Transfer Paradox
7	Forced Pendulum and Chaotic Response
8	Dynamic Response of a Mass-Spring System with Damping
9	Dynamic Response of a Rotor with Shaft Imbalance
10	Driven Oscillations of a Rectilinear Mass-Spring Damper
11	Driven Oscillations of a Torsional Pendulum
12	Thermal System Response and Effective Heat Transfer Coefficient
13	Natural Convection and Boiling Curve for a Platinum Wire
14	Car Suspension Mechanism

2.1. Compulsory exercise

There will introduce an experiment of suspension. Students are to measure and study the dynamic characteristics of a model vehicle suspension system treating it as a spring-mass-damper system with a single degree of freedom. Students will use an experimental model representing one quarter of a car suspension. The quarter-car suspension model can be considered as one-degree of freedom model shown in Figure 1(a). The model considers displacement of the sprung mass of the vehicle and the primary suspension stiffness and damping only. Here the unsprung mass (mass of the wheels and other components such as lower control arms) and the mass of the tires are not considered.
Students will perform calibration and, time permitting, can begin measurements to determine the characteristics of the system: the effective inertia of the system control arm, the spring stiffness k and damping coefficient c. And students will complete the measurements to determine the characteristics and measure the system’s driven response[6].

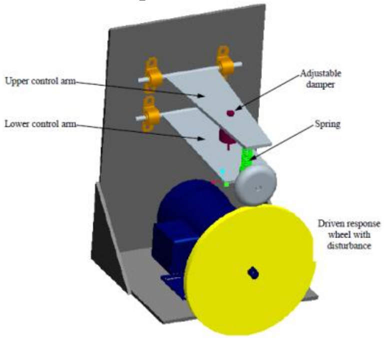
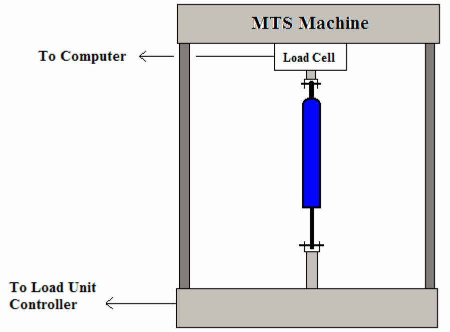


Fig. 1 Experimental test stand for one quarter of a vehicle suspension system

2.2. Final Projects

In particular, students in different groups were required to design innovative projects besides the regular three experiments. Before the start of all the projects, proposals submitted by students have to be approved by the instructor. The experimental content is very flexible and fairly up to students. Here is a typical example of a student project to study the damper performance:
The purpose of this experiment is to explore damper compression and stretching force and two kinds of shock absorber damping force was calculated in 10 mm/s and 20 mm/s. Process: the MTS to produce a triangle wave, amplitude 4 mm, high-speed test frequency is 1.2 Hz (20 mm, low-speed test 0.6 Hz)



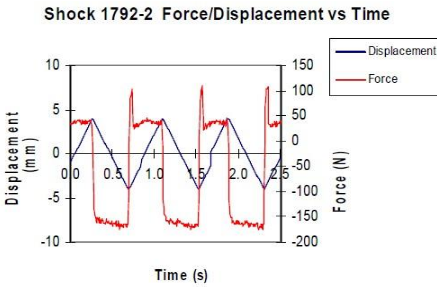


Fig 2： Experimental test stand and record

3. Several Inspirations

This course help student improve proficiencies to: 1) Design, assembling, and conduct an experiment; 2）Data analysis and results presentation. The following skills can be improved: 1) the understanding of control theory and data acquisition electronics, 2) experiment design, 3) calibration and error analysis, 4) assessing the applicability of theories and the impact of secondary experimental variables, 5) the technical writing and professional presentation. And there something inspires us mostly.

3.1. Interdisciplinary

There are various options for the experiment topics, such as the heat transfer, fluid mechanics, and dynamics, not simply our traditional mechanical experiments. Student can have comprehensive understandings of various mechanical engineering systems from these experiments. . Even one single experiment can cover mechanical system, hydraulic system, and data processing of the control theory

3.2. Downscaled model or simulator

Downscaled models or simulators are developed for most of regular experiments, such as wind tunnel, vehicle suspension, and so on. Therefore, the requirement of the lab room can be minimized very much. Comparing with the real wind tunnel, the experiment can be easily done with the wind tunnel model by only 3 or 4 students, while the same mechanism can be illustrated as well.

3.3. Systematic problem solving

In this course, the capability of students will be improved in the problem analysis and problem solving. During the experiment, a lot of issues have to be figured out by students themselves, such as what to be tested, how to measure the results and how to process the data. This kind of capability is very critical during solving practical engineering problems. During these experiments, students will not only learn the method and idea to solve practical engineering problems, but also get the sense as a competent engineer.

3.4. Innovation

Besides the mandatory exercise, the optional experiment design requires student to design experiment procedures, select experiment set-ups, and configure the test system. Then, the results of experimental will be analyzed by students themselves. Therefore, all the problems generally have to be solved by students themselves as well, so that students' ability of imagination and innovation can be improved.
In recent years, with the deepening of our teaching reform, openness and innovation is the object of our teaching methods. Higher requirements were put forward to higher engineering education, especially in the aspect of cultivating engineering practice ability. Experiences and methods of experiment teaching are worth learning from foreign universities.

4. Acknowledgement：

Jiangsu Overseas Research &Training Program for University Prominent Young & Middle-aged Teachers and Presidents
Key educational reform project of Jiangsu University: Science &Technology Innovation Activates and Innovation Ability Training
Key Disciplines Construction Project of Jiangsu Province

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