A METHOD TO TEACH AN INTRODUCTORY ENGINEERING COURSE

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1. INTRODUCTION

Today's easy accessibility and vast expansion of the Internet technology has brought fundamental changes to the way many services and operations are performed, and education is not an exception. Presently, distance learning, on line instructions and teaching, and web-based courses are common, and techniques have been developed to make the Internet an efficient educational tool. One of the strengths of the Internet technology that helps teaching a subject is its vast area of coverage of the knowledge and information about almost any subject. This provides a tremendous freedom of choice of the subject, and the level of its depth and rigor. It is a big library and its search engine is under one's fingers with amazing speed and ease of accessibility. However, nothing is perfect! Like any other tool and facility there are some disadvantages and shortcomings to be aware of in the Internet access. This technology is certainly new and still under development, and we need to understand its strength and weaknesses to use it to the best possible way. Typically, the subject matters and the information are not addressed in the Internet exactly the way they are addressed in a book or a course material. Even if a complete subject is covered in a series of articles in the Internet, with many links and referrals, it is not easy for a beginner to effectively follow. The other difficulties are commercialization, marketing and advertisement that are often mixed with requested materials, and often confusing. Many marketing gimmicks and pitfalls mixed with the information usually end up selling certain product or services rather than providing unbiased knowledge to the reader. In short, one finds more subjective materials on the Internet that objective ones. In addition, one may still need to refer to professional books and articles when it comes to theory and more analytical and rigorous materials.

One way to efficiently use the Internet technology for teaching is to first organize the course with its objectives and purpose, with contents and coverage, and the level and depth the course is designed to cover. This is very similar to organizing a book with chapters and even with sections in the chapters. The second job is to fill up these sections. Here is the place that accessing the Internet helps. Materials on the Internet are just like shelf components that are used to design and construct a functional system. Filling up the sections is, in fact, a step to put the components together and fill up the holes to deliver an effective educational package. In designing an Internet assisted course we may not often get what we need, from the Internet, or some other factors such as copy rights may prevent us from accessing certain materials. In such cases, and in order to

maintain the flow and continuity of the subject, we need to cover the rest from other sources of information, such as books and class notes. Here we simply must show that although there is no need to reinvent the "wheel", but the "wheel" and other parts available on the Internet often need to be customized and substantiated with other materials separately provided.

The other issue in designing, say, an engineering course is the experimental vs. theoretical aspects of the course. What are the applications, and how can the students run experiments on the subjects? Typically, the Internet is rich in simulation and simple modeling that helps to teach introductory courses with examples and running simulations on the subject. Again, to better use the Internet resources we need to search, find and use the experiments and simulations that help to understand the materials, and place them in a proper order for the students.

Here is a number of specific features that the courses with the Internet access provide:

- *Connectivity and Integrity*: Although the materials in the course may form a complete and independent educational package, but they are connected to a vast sea of information on the Internet. It can become a part of a bigger body; all integrated, and can particularly helps students of all levels to get what they want. For example, for those with less background it helps to tap into more introductory and rudimentary materials for review. On the other hand, for those with higher level of understanding and ambition the package can help to get access to more advanced materials on the Internet.
- *Visibility and Accessibility*: The course and materials are visible and accessible not only by the students in the class but also by all those who have permission to access. In addition, in an open communication environment, such as e-mail facility, this can help to bring new ideas, new updates, and new applications suggested by those interested, into the course.
- *Modification and Updating*: We have already talked about this feature. This is similar to compare a running steam versus a pound of standing water. A course in open gets more challenged and is revised more than one thought in a traditional way.

2. AN INTERNET-ASSISTED INTERDISCIPLINARY COURSE

In particular, designing an Internet-assisted interdisciplinary engineering course can get rather involved, and this is because the subject can get spread across several disciplines. One method to reduce the complexity is to follow a top-down design, with understanding that in each step, in the course development, we need to keep in mind the interdisciplinary nature of the course. We start from the objectives and the coverage of the course. The next step is to define the sequence of stages that each fulfills smaller objectives and they overall cover the entire material and address the final objectives, again, just like the chapters in a text. The third step in the course design is to choose the components and parts for each chapter. Here is where we can use some selected external sources and materials on the Internet along with our own to cover the subject. Fourth, to provide continuity and proper understanding of the subject we need to follow a pattern of presentation that helps the students to gradually move from simpler parts to higher level, and stop when they reach to the level of rigor intended for the course. What really makes this method different from leaving the students to surf the Internet and find their own choice of materials is a

guidance to make this a proper choice, and also fill up the gaps with enough theory and practice to fulfill the objectives, and not stick to the sites.

3. DIGITAL CLOCK

As a case study, we have selected the development of part of an interdisciplinary course, UEET101, offered as an introductory course for engineering majors at Northern Illinois University. The course is intended to help the undergraduate engineering students to get familiarized with problems and activities in electrical, mechanical, and industrial engineering and to teach them about some engineering projects of multi-disciplinary dimensions. One of the topics presently covered in the course is Digital Clocks. The choice of this topic is relevant because of clock's interdisciplinary nature, relative simplicity, wide spread use, and easy to build. The topic is basically divided into two main parts, mechanical clocks and electric clocks, and the third part talks about the construction of a digital clock and its manufacturing aspects.

3.1 Mechanical Clocks

In the part related to the mechanical clocks first the history of division of time into slots with different sizes and units is discussed. Below is an excerpt from the lecture covering this part, with reference to some Internet sites.

> The clock is one of the most important discoveries in the history of civilization. The division of time into slots with different sizes and units is fundamental to the operation of society. Even in ancient times, humanity recognized the necessity of an orderly system of chronology. Hesiod, writing in the 8th century BC., used celestial bodies to indicate agricultural cycles. Later Greek scientists, such as Archimedes, developed complicated models of the heavens--celestial spheres--that illustrated the "wandering" of the sun, the moon, and the planets against the fixed position of the stars. The process of measuring time has progressively become more accurate, and the devices more localized ever since.
>
> However, in our modern time, the time is predominately measured by mechanical, and recently by electric and electronic clocks.
>
> For further reading please refer to the following links:
>
> - A walk through time
> http://physics.nist.gov/GenInt/Time/time.html
>
> - Time and frequency division
> http://www.bldrdoc.gov/timefreq/general/exhibits.html
>
> - Clock and time, History of timekeeping
> http://www.ubr.com/clocks/hist/hist.html

In the next section a wind-up alarm clock is introduced and some details of the internal structure of the clock are displayed. Figure 1 shows some sample views of a wind-up alarm clock. In this introduction the main parts of a wind-up alarm clock and the way they perform are discussed. To

enhance their knowledge some related Internet sites are also provided for the students. An example of a related site is:

http://home.howstuffworks.com/inside-clock.htm

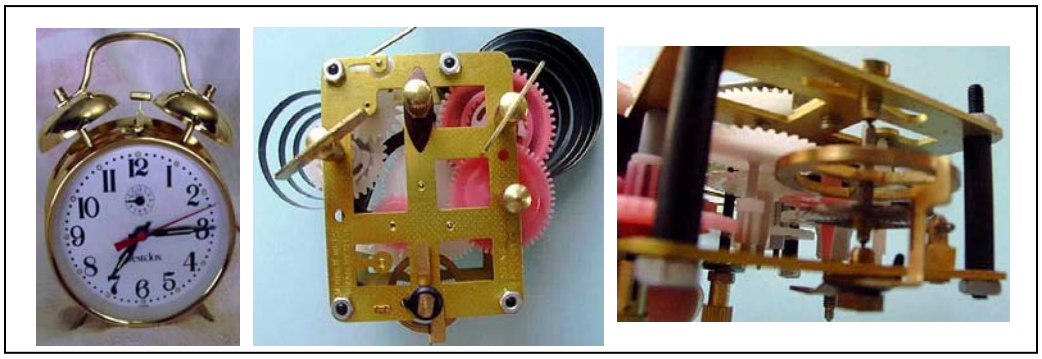


Figure 1: Some sample views of a wind-up alarm clock.

In the next section pendulum clocks are introduced with some details on the dynamics of a pendulum. Several related sites such as the following site are useful for students to learn the theory and practice the motion of a pendulum.

http://monet.physik.unibas.ch/~elmer/pendulum/rpend.htm

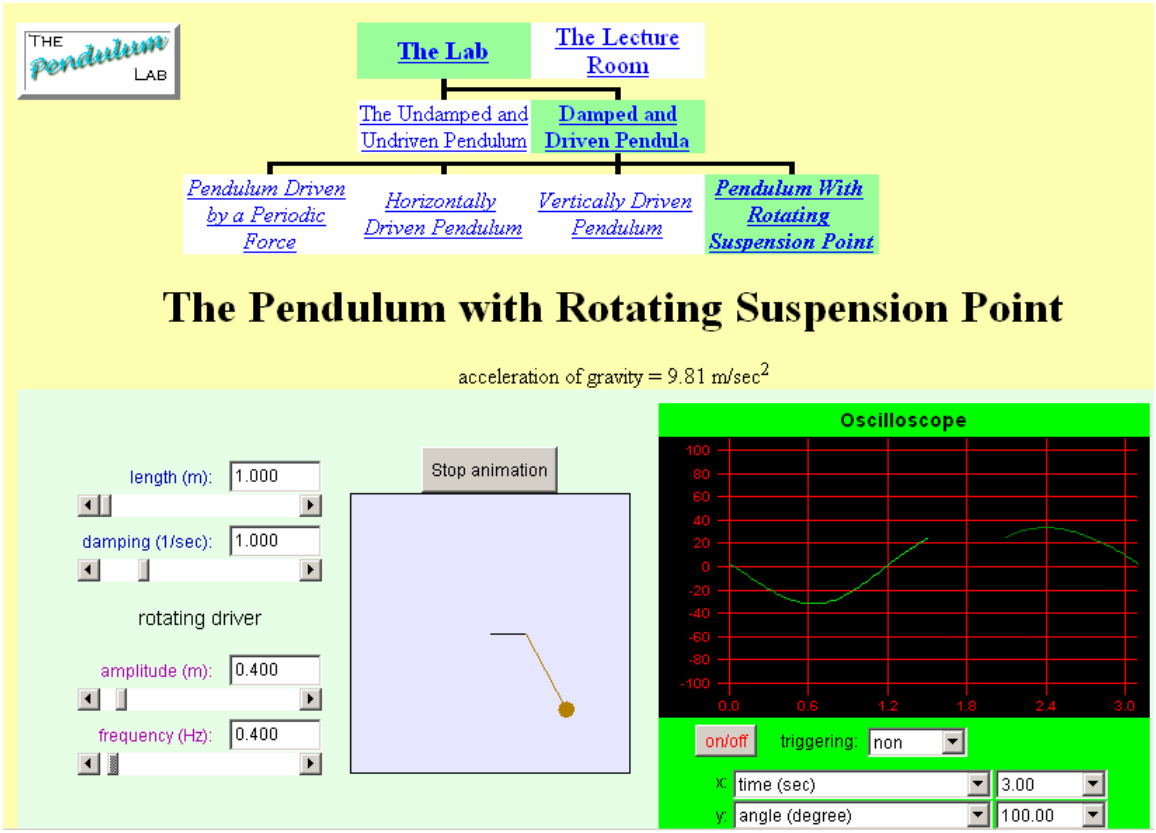


Figure 2: A view of a pendulum simulation lab in the Internet.

Below is an excerpt from the lecture on pendulum.

Pendulum clocks have been used to keep time since 1656, and they have not changed dramatically since then.

First, let us see how a pendulum works, and how the motion of a pendulum is transferred to the motion of clock handles? Figs. 4 (a) and (b) show a pendulum with its escapement in its two extreme positions. As we can see, because the wheel (escapement) is energized to turn only in one direction it operates such that it transfers the circular motion to the clock handles, one step at a time

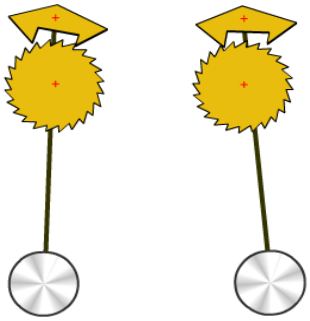


Fig. 4 - -shows how a pendulum transfers its motion to a turning wheel

For further information please refer to the following site.
http://home.howstuffworks.com/clock.htm

The subject is continued by introducing the gear system in the mechanical clock. The ratios of 1/60 in both seconds to minutes and minutes to hours, and finally hours to AM and PM are discussed, and demonstrated in a virtual lab, presented in site http://www.howstuffworks.com/gears.htm. Other issues in a pendulum clock such as power springs and weights, and display system are also discussed in the course.

The last issue to study in a mechanical clock is the precision and adjustment of time. In the class, we have already introduced two types of mechanical oscillation that are used in mechanical clocks, namely, the oscillating wheel, and the pendulum. We have already discussed the theoretical aspects and we have characterized both types of oscillation. The students know the dependency of the period of oscillation to some parameter in the clock. For example, the length of the pendulum affects its period of oscillation, or in the oscillating wheel, it is the length of the spring that must be adjusted for the period.

3.2 Electronic Clocks

Study of mechanical clocks helped us to understand the way a clock works. We also studied parts such as clock oscillation, clock speed reduction, and display. Our next step is to move into electronic clocks. Electronic clocks are divided into two categories: analog clocks and digital clocks. The major distinctions between these two categories are discussed in the class. We then briefly introduce the analog clocks and their major components. To understand the cause of constant speed in rotating clock arms the students need to know about the line power and synchronous (continuous or stepwise) motors, predominantly used in electric clocks. Here the

students understand that an analog clock is very similar to a mechanical alarm clock, except for the oscillation wheel, which is replaced by a synchronous electrical motor. To fully grasp the idea the student learn about the domestic 110 volt, 60 Hz line power in this section, and how the precision in line frequency brings precision to an electric clock.

We next move into fully digital clock with crystal oscillation. Below is an excerpt from the lecture on Quartz Crystal.

Quartz Crystal

Quartz Crystal is an essential part in digital watches. It takes care of the oscillation in the watch. IC crystals, manufactured from natural crystals, are structures that exhibit a difference in potential across the opposite face of the crystal when mechanical stress is applied across one face of the crystal. Figure 8 shows Quartz material in its crystallized formation.

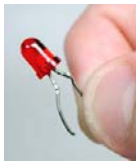
Fig. 8 Quartz material in its crystallized formation

Digital logic gates are the next components that the students need to know in order to understand how these gates are replacing the gear system in the mechanical clocks. The concept of counters stepwise reducing the oscillation each time by a factor of 2 is quite comparable with reduction of the rotational speed by a gear system.

Light emitting diodes, commonly called LEDs, are real heroes in the electronics world. They do dozens of different jobs and are found in all kinds of devices. Among other things, they form the numbers on digital clocks transmit information from remote control, light up watches and tell you when your appliances are turned on. Collected together, they can form images on a jumbo TV screen or illuminate a traffic light.
Basically, LEDs are just tiny light bulbs that fit easily into an electrical circuit. But unlike ordinary incandescent bulbs, they don't have a filament that will burn out, and they don't get especially hot. They are illuminated solely by the movement of electrons in a semiconductor material, and they last just as long as a standard transistor.

Display

Seven Segments are actually LEDs in bar shapes. As the name suggests, seven of these LEDs form an “8” shape that can show from 0 to 9, depending which LEDs are turned on or off. Figure 11 shows a set of seven segments showing digital numbers from 0 to 9.



Digital displays are the next components in the digital clocks that replace the arms in mechanical clocks. Here the students get familiar with LED and LCD displays. Seven segment LED displays are introduced and their use in displaying minuets and hours are discussed. Below is a sample lecture covering the LED display of numbers 0 to 9.

This concludes the major parts in a digital clock. Our next attempt in the class is to put the parts together and actually build the clock. Below is a sample lecture about the construction of a digital clock.

Building a Digital Clock

Next, we can get a digital clock IC and with all necessary clock components, that we discussed, we can construct a complete clock of our own. Figure 12 shows a recommended circuit for constructing a digital clock with hours and minutes displayed.

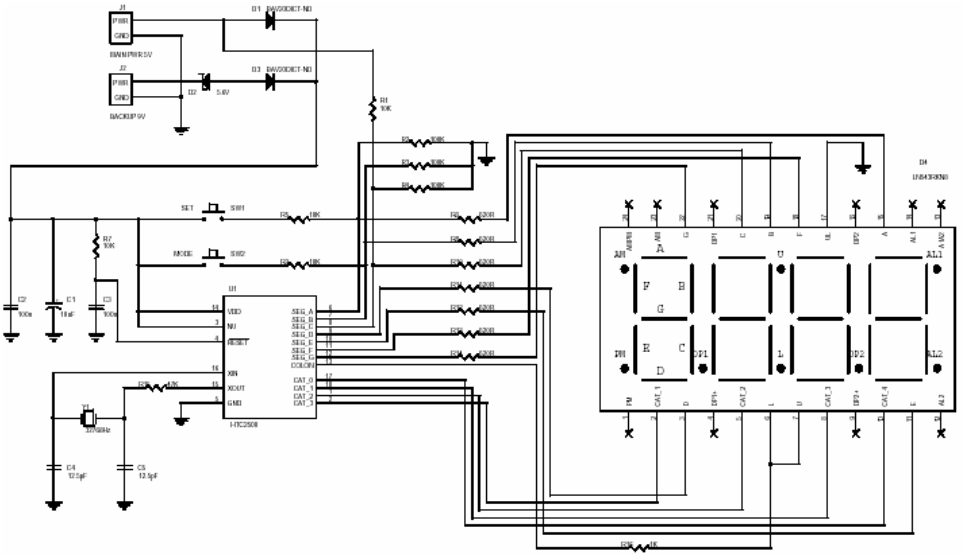


Fig. 12 – A digital clock circuit diagram.

For more details please refer to the following data sheets.
http://www.hightechips.com/Download/HTC2500.PDF

Finally, the economy and manufacturing aspects of a digital clock is discussed in the class, and the students get familiar with component prices, labor, tools, and other manufacturing costs for a finished product. The students understand the rule of mass production and labor cost compare to the cost of a hand made digital clock.

4. CONCLUSION

A method is presented to design a course, or part of a course, for early undergraduate engineering students. The course is intended to be Internet-assisted and of interdisciplinary in nature. As a case, the study of clocks is selected as part of the course. The history of clock development and the classification of clocks into mechanical and digital clocks are discussed.

Finally the design of a digital clock is discussed, all as part of an early undergraduate engineering course, UEET101, offered at Northern Illinois University.

REFERENCES

How to build a Digital Clock, http://www.iguanalabs.com/clock.htm.

The JavaScript Source: **Clocks**: **Digital Clock** http://javascript.internet.com/clocks/digital-clock.html

Guide to use the PIC Circuit to design **Digital Clock** http://www.interq.or.jp/japan/se-inoue/e_pic6_7.htm