

Teaching an Interdisciplinary Engineering Course to Help Students to Better Select Their Majors

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Abstract - This article presents a method to design an Internet-based interdisciplinary course, or part of a course, for early undergraduate engineering students. The objective is to emphasize on different aspects of a subject to give the students enough knowledge and experience to help them to choose their area of interest in engineering, and to motivate them to carry on using the Internet for other and similar studies. This method tries to combine the class instructions with the Internet tools, and to keep a balance between the two. That is, while supported by the instructional format, the Internet provides wealth of simulated experiments and design examples that are typically beyond the classroom capabilities. Study of digital clocks with all its long history and development pattern is selected as a case study for an introductory engineering course, UEET101, offered at Northern Illinois University. Practicality, simplicity and interdisciplinary (electrical, mechanical, and industrial) nature of the subject help students to get exposed to and experiment with a product of this nature before they make their career decision.

Index Terms – Internet-based, Interdisciplinary Course, Engineering Design, and Digital Clock.

INTRODUCTION

How can we teach our freshmen students to experiment, design and even construct devices of their own interest by following the class instructions with the help of vast knowledge and information on the Internet? Today's easy accessibility and massive expansion of the Internet technology has brought fundamental changes to the way many services and operations are performed, and the education is not an exception. One may argue that, for the most part, the information on the Internet does not carry enough depth and rigor to be replaced for a college level course. This is true if we solely relied on the materials on the Internet. But the purpose in our method is mainly to use the Internet for the simulated experiments that helps students to better grasp the materials presented in an instructional-based class environment. In addition, being offered at the early college level the materials do not need to be much analytical and rigorous.

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 information and the knowledge about almost any subject. This provides a tremendous freedom of choice of the subject, as well as the level of its depth. It is a big library and its search engine is under one's fingers with amazing speed and ease of accessibility. However, nothing is free, and nothing is perfect! Like any other tool and facility, there are some disadvantages and shortcomings that have to be addressed in the Internet access. This technology is certainly new and still under development, and one needs 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, with many links and references 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 than 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. Materials on the Internet can be very judgmental, and sometimes the desire to get the viewers' attention may get the main purpose out of focus.

Our method 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 that 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 where accessing the Internet helps. Materials on the Internet are just like shelf components that are used to design and construct a functional unit. We need to design the course, sketch its structure, put things in order, and look for the course materials to put them in place. The Internet components, in fact, come at the front end of this process to fill up the gaps for delivering an effective educational package. In designing an Internet assisted course we may not often get what we need solely 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 of the material 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 subject? Typically, the Internet is rich in simulation and simple modeling examples that helps to teach introductory courses. Again, to better benefit from the Internet resources we need to search, find and use the related 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*: Normal courses typically form a complete and independent educational package, but they lack continuity, and renew-ability. In case of an Internet-based course, however, connection with a vast sea of information on the Internet adds to the course dynamics and its advancement. It can become a part of a bigger body; all integrated, and it can particularly help 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, and for those with higher level of understanding and desire the package can help to get more advanced materials from 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 an open communication environment, such as e-mail facility, this visibility and accessibility 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 pond of standing water. A course in open gets more challenged and is revised more than one taught in a traditional way.

AN INTERNET-ASSISTED COURSE

Here, through an example, we show how to combine the class instructions with the Internet tools that, while supporting the instructions format, it provides wealth of simulated experiments and design examples that are typically beyond the classroom capabilities. How can we teach digital clocks to the freshmen engineering students, and have them to experiment and understand many aspects of the system without going into much of the theory? Coming all the way from the wind-up alarm clocks, the power springs, the

dynamics in a pendulum clock, the gear system, the crystal oscillation, logic gates and to the display system in an electronic clock is certainly a simple but long interdisciplinary journey that helps students to see their preference and can help them to make their choice. We also discuss methods and means that allow the students to build their own device, from different level of complexity. For example, to build a digital clock one may only need to get four components, digital clock chip, display, crystal oscillator, and battery pack, and assemble them to make a digital clock. On the other hand, one can start from more basic parts and design a clock from, say, standard gates or even by using a microcontroller chip.

In practice, 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 determine 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 are scope and guidance. Scope is to open the field with its objectives for search, and guidance to provide the students a road map to proceed.

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 and marketing aspects.

I. 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, an excerpt from the lecture covering this part, with reference to some Internet sites, is presented.

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>

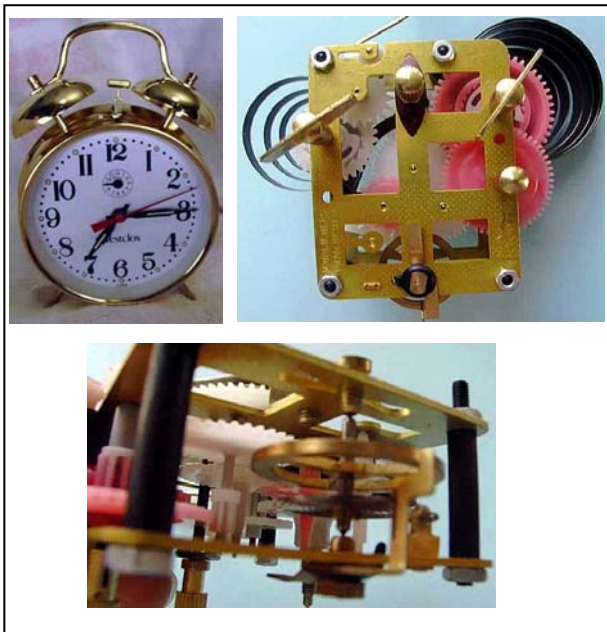


Figure 1: Some sample views of a wind-up alarm clock.

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

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

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>

Below is an excerpt from the lecture covering the pendulum motion with reference to an Internet site.

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

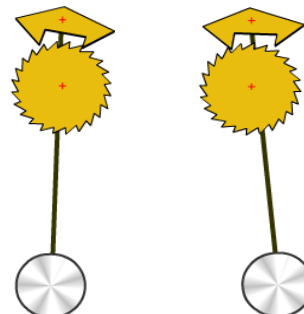


Fig. 4 - -shows how a pendulum transfers its motion to a turning wheel

For further information please refer to the following site.

<http://home.howstuffworks.com/clock.htm>

Figure 2 is an image of a pendulum simulation Lab, with different variables that experimentally demonstrate the motion and timing in a pendulum with variety of suspension points and damped/undamped situations.

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>.

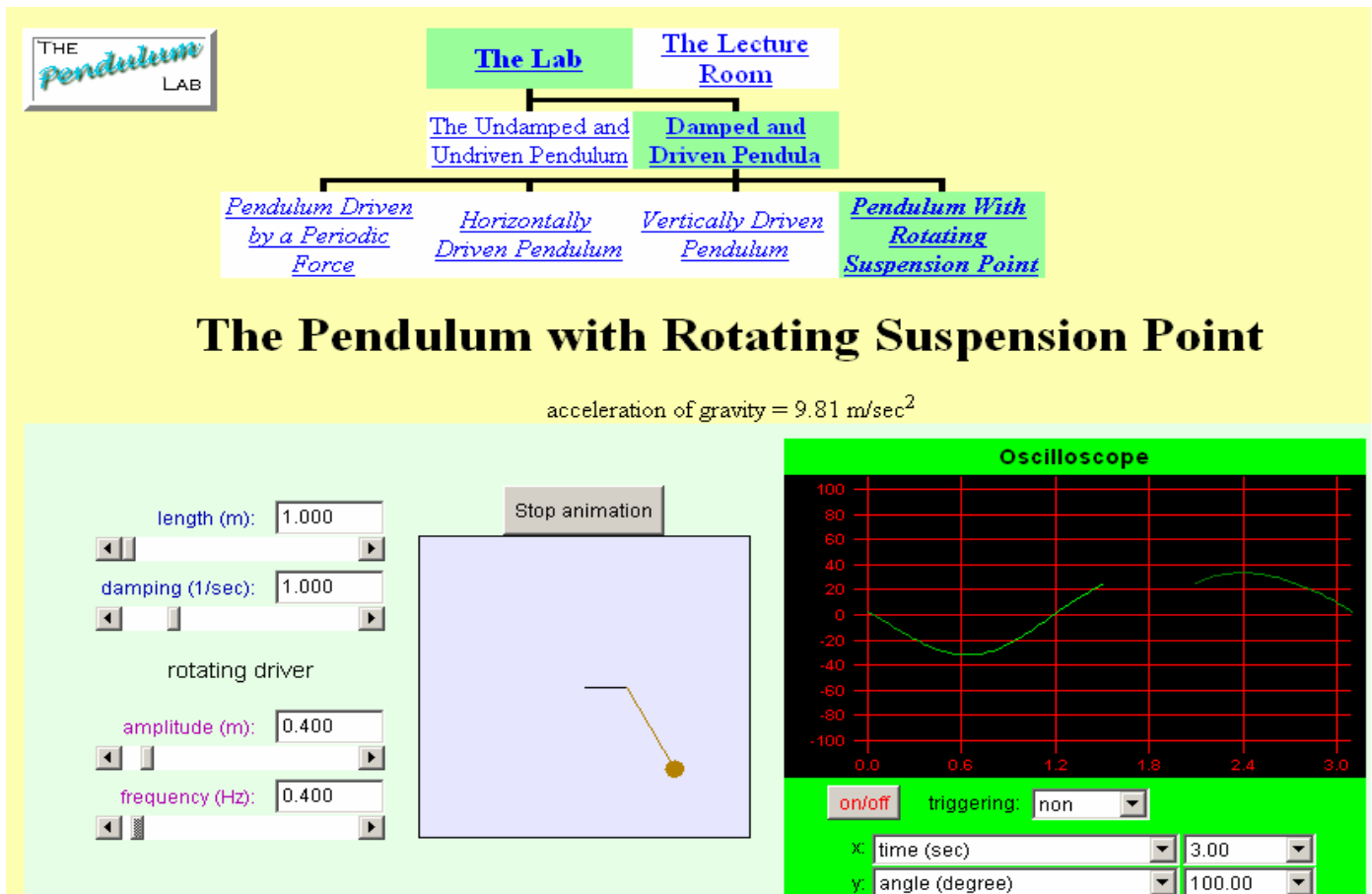


Figure 2: A view of a pendulum simulation Lab, with different variables to demonstrate the motion and time.

The last issue to study in a mechanical clock is the precision and adjustment of time. We introduce two types of oscillators that are used in mechanical clocks, namely, the oscillating wheel, and the pendulum. We discuss the theoretical aspects and characterize 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.

II. 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 learns 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 clocks with crystal oscillation. Below is an excerpt from the lecture on Quartz Crystal.

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 frequency, each time by a factor of 2, is quite comparable in a gear system.

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 minutes, hours, AM and PM are discussed. Below is a sample lecture covering the LED display of numbers.

III. Construction of Digital Clocks

As stated earlier, there are many ways to construct a digital clock. However, because of an introductory engineering course only two kinds of designs are discussed in this class.

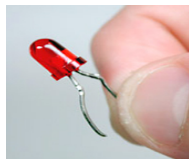
Quartz Crystal

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

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.



Seven Segment Displays

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.



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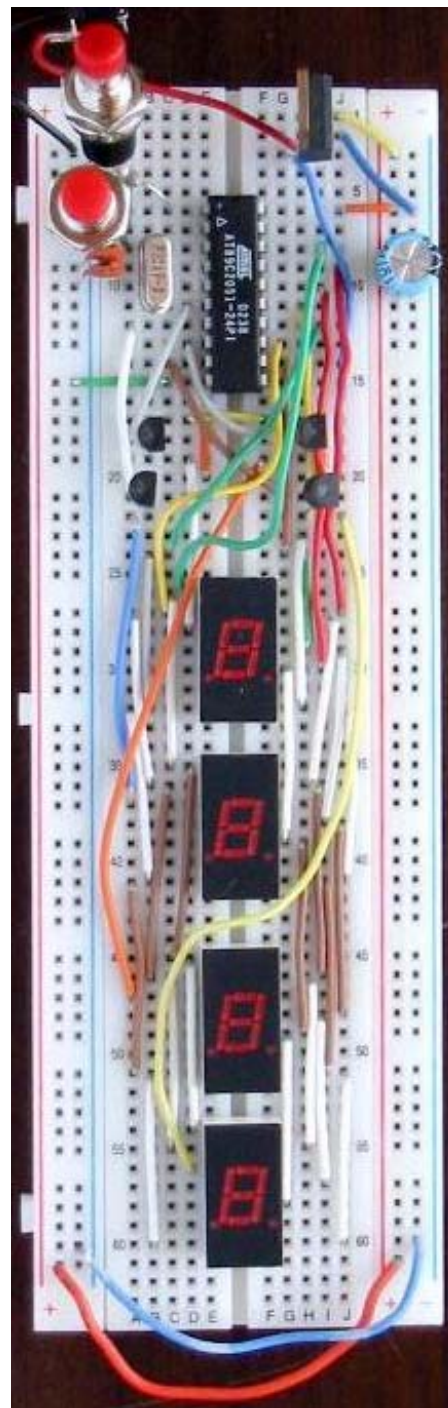


Fig. 3: A clock design uses a 2051 microcontroller

One method is to use microcontroller to construct a clock, and the second method is to use an already manufactured clock chip.

For the first method we can get the instruction from <http://www.iguanalabs.com/>. Here the design uses a 2051 microcontroller to build a digital clock with 7 segment displays. The procedure is interesting because the students can get a breadboard, some components such as transistors, resistors and capacitors, some connecting wires, and four 7-

segment displays, and start building their own circuit. The design starts by building the circuit with a 2051 microcontroller sitting in the center, as shown in Fig. 3.

In the second method we use all four types of components, crystal oscillator, speed control ICs, digital display, and power to construct a digital clock. Our next attempt in the class is to put the parts together and actually build the clock. Below a sample lecture about the construction of a digital clock using the second method is shown. 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. Below, shows an excerpt from the class lecture notes covering the pricing of a small project building a digital desk clock.

CONCLUSION

A method is presented to design an Internet assisted course, or part of a course, for early undergraduate engineering students. The materials in the course are formatted to jointly use the class instructions as well as utilizing the Internet access for information, simulation, and experiments on the subject that are usually beyond the classroom capability. The method is particularly designed to work best with interdisciplinary subjects, and to help the students in their early career to select their major. 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, electrical 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.

Items	Unit Price in \$
Digital clock chip and socket	4.50
Crystal oscillator and the circuit	2.80
Seven segment displays (4)	2.60
Battery and battery holder	3.30
PC board and casing	5.75
Other charges	2.50

Total	21.45

Add your time spent on the project and calculate the total price for a digital clock you build, and compare it to your choice of a desk clock bought from a department store.

REFERENCES

- [1] How to build a Digital Clock, <http://www.iguanalabs.com/clock.htm>.
- [2] The JavaScript Source: Clocks: Digital Clock <http://javascript.internet.com/clocks/digital-clock.html>
- [3] Guide to use the PIC Circuit to design Digital Clock http://www.interq.or.jp/japan/se-inoue/e_pic6_7.htm

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.PDFH>