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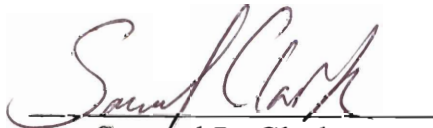
Internet Teaching Module: ES2503
Introduction to Dynamic Systems

An Interactive Qualifying Project
submitted to the faculty of
Worcester Polytechnic Institute
in partial fulfillment of the requirements for the
Degree of Bachelor of Science


Submitted to:

Project Advisor: Zhikun Hou, Ph.D., WPI Associate Professor

Submitted By:


Samuel L. Clark


Jason A. Gadebusch


Robert J. Sweeney


Blain D. Smith

Date: March 10th, 2003


Zhikun Hou

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1 Introduction

ES2503: Introduction to Dynamic Systems is a sophomore-level course offered at Worcester Polytechnic Institute. It is the third and final course “in the engineering mechanics sequence that serves as a foundation for other courses in mechanical engineering” (WPI Undergraduate Catalog, p.194) and deals with “the kinematics and dynamics of particles and rigid bodies which move in a plane.” (WPI UC, p.194) The course builds on the knowledge gained in the Static Systems course (ES2501), which is also a prerequisite for the Stress Analysis course (ES2502). All three courses are required credit for students seeking an undergraduate degree in Mechanical Engineering, regardless of concentration.

Students who have already participated in the Dynamic Systems class initiated this project. The students felt that this was one of the most intense and difficult classes that may be encountered by Mechanical Engineering students in their first two years. This course covers many topics and has a workload to match, combined with Worcester Polytechnic Institute’s seven week term schedule it makes for one of the reasons the group feels the way it does about the course. Another reason is that it is one of the first courses that students encounter with problems that require a vast base of basic knowledge that may, or may not, be a bit ‘rusty.’ As a result of their own struggles with this course the project initiators decided to pursue means of providing help for current and future students who have yet to have this experience. One of the avenues for help that they came up with was a website that was constructed with the intent of providing additional

explanations and alternative views for the same topics. An integral part of this idea was that the course professor be involved in and oversee the production of the site, that way the site would be able to be constructed as a part and extension of the course.

The objective of this project was to work with the Dynamic Systems professor in an effort to lay out the groundwork for the course supplementary website. By looking at other websites that were similar in concept to what the group was looking for, the group was (after much discussion with the project advisor) able to come up with a basic blueprint for the site that would allow future project teams to add more information without having to rewrite what already existed. From there, the next objective was to start adding the content from the professor, as well as the content conceived and produced by the group members, to the site in an effort to give a few sections full functionality. This was also completed and was done to give future project teams a “roadmap,” of sorts, to follow.

An interesting point about this particular project is now that there is a foundation that details how to set up the site; it could be used to set up similar sites for different courses. For instance, a project group could pick up where this group left off on the Dynamic Systems site and another project group could initiate the same type of project for the Static Systems course. Not only would this produce many future project opportunities, it could make taking any of the courses covered a better experience.

2 Literature Review

In Kurt Vonnegut's classic novel *Player Piano* the ace machinist Rudy Hertz is flattered by the automation engineers who tell him his genius will be immortalized. They buy him a beer. They capture his skills on tape. Then they fire him (Noble, 1998). While this may be an extreme example, it does represent a basic fear that most college faculty embrace (to a greater or lesser extent) about web-based learning. By placing their knowledge and course notes online, the possibility that they have become redundant arises and the students' need to attend lectures may diminish. Trying to find some middle ground that incorporates technology advancements and traditional methods into a single educational system has been the analyzed for years (Hara & Kling, 1999).

Kling (1994) identifies "technological utopianism," which refers to "analyses in which the use of specific technologies plays a key role in shaping a benign social vision." A similar attitude is found in the history of educational technology:

Most of what we read or hear about computers in education emphasizes only one aspect, usually the good points, but occasionally the bad, to the exclusion of other points of view. This is at least partly due to the screening effect of the popular press, who favor the excitement of extremism over the calm of rationality, preferring in the name of "reader interest" to create what Monosky (1984) calls an artificial dichotomy (Ragsdale, 1988, p. 50).

Both Kling and Ragsdale caution against extreme views of technology, either positive or negative, and suggest that more socially realistic analyses are needed. (Hara & Kling, 1999)

As Wen (2002) states, “Students taking engineering courses comprehend theories and improve problem-solving skills through extensive exercises. It is beneficial [for instructors] to adopt...online [course work] so that more questions can be issued for student practice without substantial increase in teacher workload.” By integrating an online teaching module into a standard lecture-based course, the amount of additional practice for the student becomes immensely greater, especially when an online quiz section is part of it. Unfortunately, the initial setup of such a site requires a great deal of time and work by somebody and it may be too much for an instructor to do on their own. However, once the site is set up the instructor is able to maintain it with little effort (Smith & Taylor, 1995).

Another problem with discussing "online courses" is that the term seems to be used in radically (and confusingly) different ways by different people (Jackson, 2002). To maintain a sense of uniformity, the following definitions are the ones used by the group in their project:

Technology-Enhanced Learning: Learner audience has frequent opportunities to meet face-to-face with the instructor in traditional classrooms. Course is supplemented by basic online information such as syllabi, bibliographies, and notes.

Technology-Delivered Learning: Learner audience is never (or very rarely) in physical proximity to the instructor and instructor-led traditional classroom sessions are either eliminated, adjusted for some different form of non-real time interaction, or replaced with real-time “virtual classrooms.”

Blended Learning: The combination of asynchronous self-study with traditional classroom, face-to-face activity. We can easily validate this type of "blend" since traditional colleges and universities have used it for 200 years: faculty teach in live, instructor-led events and then assign homework (an asynchronous activity) as follow up.

Synchronous Learning: All instructor-led events are considered to be under this category.

Asynchronous Learning: Self Study learning experiences rely on some structured plan that directs the learner through learning experiences without real-time interaction from an instructor. CD-ROM based tutorials, paper-based correspondence and "Click-to-learn" web based systems are examples of this learning format. Traditional homework falls into this category, too.

(All definitions come from Jackson, 2002)

From these definitions it becomes simple to identify the focus of this project in terms that are congruent with the technology-based education society. This project is trying to convert the Dynamic Systems course from traditional blended learning to technology-enhanced blended learning. When the conversion is complete, the course will be able to offer its students nearly unlimited access to course-related topics provided in an asynchronous environment. With the addition of this information, the students in the course will be able to monitor their own saturation level for each topic covered. This type of environment is considered to be more conducive to academic success (Bligh, 1998).

3 Methodology

The goal of this project is to design and establish a website that can be used as an asynchronous teaching aid for the students taking ES2503: Introduction to Dynamic Systems course at Worcester Polytechnic Institute. By providing this site to both the student and the professor of the course, it is hoped that the overall experience of the course will be improved through the addition of third party views and information.

The group sought the help of the course professor, Dr. Zhikun Hou, for both project sponsorship and as a primary resource. After securing the support of Dr. Hou, the group started looking at other websites that seemed to have either similar ideas or purposes to the newly created project. Simultaneously, the group poured over myriad research papers and journal articles looking for information pertaining to the effectiveness of web-based or web-assisted learning. With the information gathered from those sources, the group used their own experiences with classes that offered a website as a teaching aid and input from Dr. Hou to generate the basic framework of the proposed site.

3.1 Viewing Similar Websites

The first research done by the group was to find and evaluate a number of different websites that were created to assist in the education of students when combined with the course lectures (the sites used and a description of what the group thought of them can be found in Appendix A). The group looked for any

similarities between the sites that might be used as a set of makeshift standards for their own nascent site. The following is a list and description of these correlations:

Basic Course Information (BCI): BCI is the ‘catchall’ for any information that has to do with the actual course. This includes the course syllabus, the instructor’s contact information, the lecture and conference schedule, any information concerning the TA’s, and etcetera.

Textbook Definitions: The majority of sites provided a section that contained a type of glossary that contained not only word definitions but also basic equations and their common uses.

Example Problems: The use of fully illustrated and explained problems ranging in difficulty from basic to extremely complex is a way of demonstrating the concepts being presented in a real application. Example problems are the biggest mainstay of all the websites reviewed.

Interactive Q/A Sections (IQAS): IQAS’s are a more advanced form of Example Problems and are usually used in conjunction with them. They contain an unsolved problem and either multiple choice answer options or a place to enter a self-derived answer. After submitting the answer, the IQAS provides either a confirmation of success or a message informing the user of error and then shows the complete solution to the problem.

Course Related Files (CRF): Enough of the sites reviewed contained CRF’s for them to be considered in this listing. CRF’s can be anything from practice or previous quizzes to homework assignments and their solutions.

3.2 Reviewing Research Papers & Journal Articles

By exploring recent research papers and journal articles the group was able to learn what made for the most effective way to integrate web-based technology into the teaching of a post-secondary course and what the current views of those most involved in the subject were.

The biggest finding of the entire group's research in this area was that completely asynchronous courses have extreme difficulty in maintaining enrollment. Apparently the isolation that results from trying to gather all knowledge from text and pictures is enough to discourage all but the most stalwart scholars.

"Content-high" e-learning is frequently referred to as "shovelware" (lots and lots of material on Web pages) with very little instructor interaction and virtually no student-to-student interaction. Dropout rates tend to be very high, often between 40-50%. Unfortunately, this design philosophy is quite common in first generation online courses from most institutions. High production values (animated graphics, pretty page designs) do little or nothing to offset the monotony of one-way information. (Jackson, 2002)

However, the group found that if a site was used in conjunction with course lectures and inter-student communication its chances of being a successful teaching/learning tool were greatly increased.

"Process-high" e-learning, in contrast, involves considerable interaction & dialog among students and instructors. Although some designs encourage this instructor/student dialog throughout these courses, other designs emphasize the role of instructor as initial facilitator who becomes hands-off once the group is going. Dropout rates in these courses and programs tend to be much lower than "content-high" learning, with attrition rates of 3-5%. (Jackson, 2002)

Upon learning this, the group decided to make sure that it would be difficult to use their website as a substitute for the course lectures and conferences. This would hopefully reduce the number of students could possibly justify non-attendance at the course lectures by reasoning that the website contained all the knowledge and information needed to succeed in the course. The possibility that some students will not receive a passing grade in the course because they decided

to try to glean all information from the site and not attend lecture does exist, but it should be made clear enough that to do so is at the risk of the student and thereby diminish the number that try.

3.3 Using Group Experience

Since the students that comprise the project group initiated this project, it is possible for them to use their own experiences as post-secondary students as a resource. As a group they decided upon two more criteria for their website that were not found in the majority of other similar sites (listed above). These criteria are:

Third Party Input (TPI): TPI is defined as any information in the website pertaining to the course that is not provided by the instructor or textbook. This can be as insignificant as a TA's solutions to a problem set or as major as another professor's notes or website covering similar material. The group's reason for including TPI (in this case, their own) is that it provides an alternative point of view for the students in the course that might *not understand* the technique used by the instructor (which is often dictated by the textbook).

Instructor's Class Notes: The inclusion of the class notes may seem like an invitation to skip the lecture entirely, but that is not the case. Most students know that instructors often stray from their notes during lecture in order to better explain a concept or to answer a question from the class. The reason for including the notes in the website is that allows the students to concentrate more on what the instructor is try teach rather than on how to write it all down on paper at the same speed that it is being presented.

3.4 Communication with Instructor

Finally, the group used direct communication with the course instructor, Dr. Hou, as a primary resource. This provided the group with information about

the course and teaching it from a point of view that none of them could possibly imagine. Through weekly correspondence with Dr. Hou, the team was able to shape the website in a manner that would be conducive to both the students using it and person maintaining it.

The other advantage to working with the course instructor was that the group gained access to information and documents that would be otherwise unprocurable in a timely fashion. This includes the course lecture structure, the instructor's class notes, and the course homework assignments.

3.5 Summary

The methodologies used to obtain the background, initial, and any other information helped bring into being the website that this project is based upon. By using a combination of previous works, the group's knowledge, and the instructor's advise it was possibly to create the framework needed for this project. By reviewing what others had already researched in the area of web-based learning, the group was able to avoid making both design and logic errors that have already been encountered. As with any project, it is impossible to make forward progress if there is no known starting point and this research made it possible for the group to define an origin.

4 Design and Results

After reviewing other websites that were similar in concept to what the group wanted to produce and picking out the major components for their own embryonic site; the next step was to put it all together into coherent, flowing system. By referring to the layout of the same similar site and making use of recent advances in web design technology, the group was able to generate a site that conveyed the content to the viewer in a satisfactory manner.

As a guide for future groups, the current group completed one topic in full and posted it on the site. The basic format for each topic is as follows:

- All class lecture notes related to the topic from the instructor
- A basic explanation/development of the topic produced by the group
- At least one example problem produced by the group
- At least one interactive quiz produced by the group
- Any homework assignments/solutions attached to the topic

The site was designed so that each of the subsections, created by the information needed by each topic, were all easily accessible at anytime. To accomplish this, the site contains a navigation bar on the left hand side of all its pages (see Figure 1). This navigation bar scrolls down when the viewer does so that it is always in sight.

An example of the site pages and the design considerations that accompany them follow:

1. The Homepage

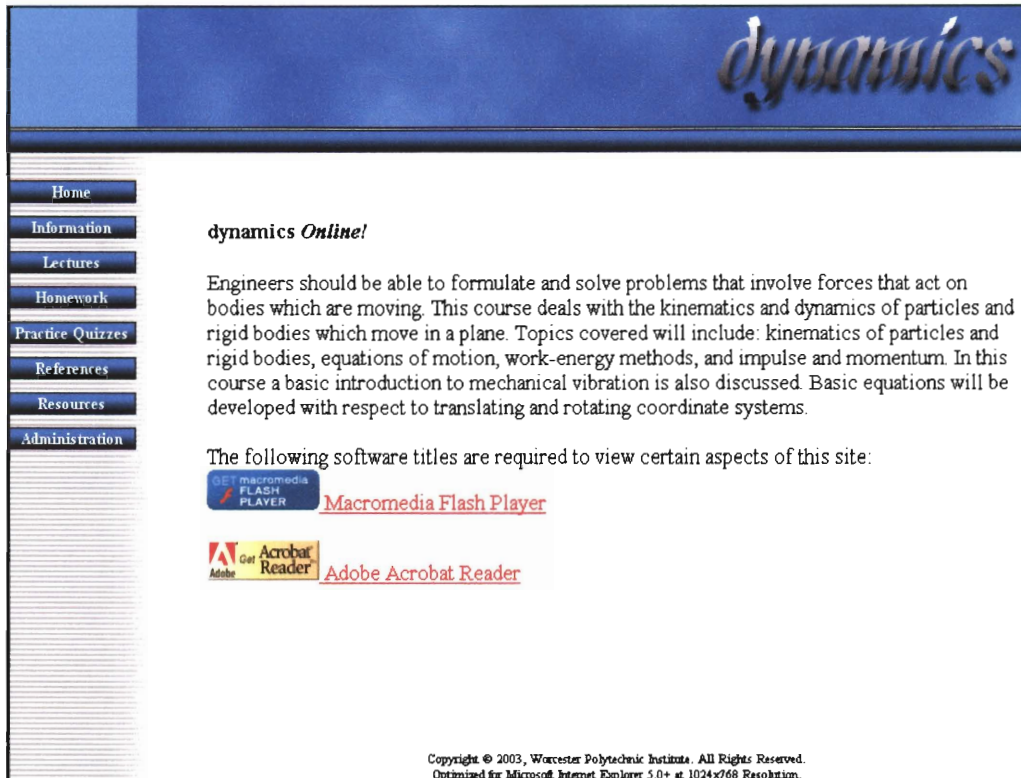


Figure 1: Homepage

This is the first page encountered first by all visitors to the site. On the left is the ever-present navigation bar and all of its options. A large portion of this page is designated for the course description that comes from the Worcester Polytechnic Undergraduate Handbook. Under the main text of the page there are two links to commercial websites. These commercial websites provide free web browser plug-ins that allows the site visitor to properly view the site in the manner in which it was designed. If the site visitor's computer does not have the required plug-ins, they can be downloaded by following these links.

2. The Information Page

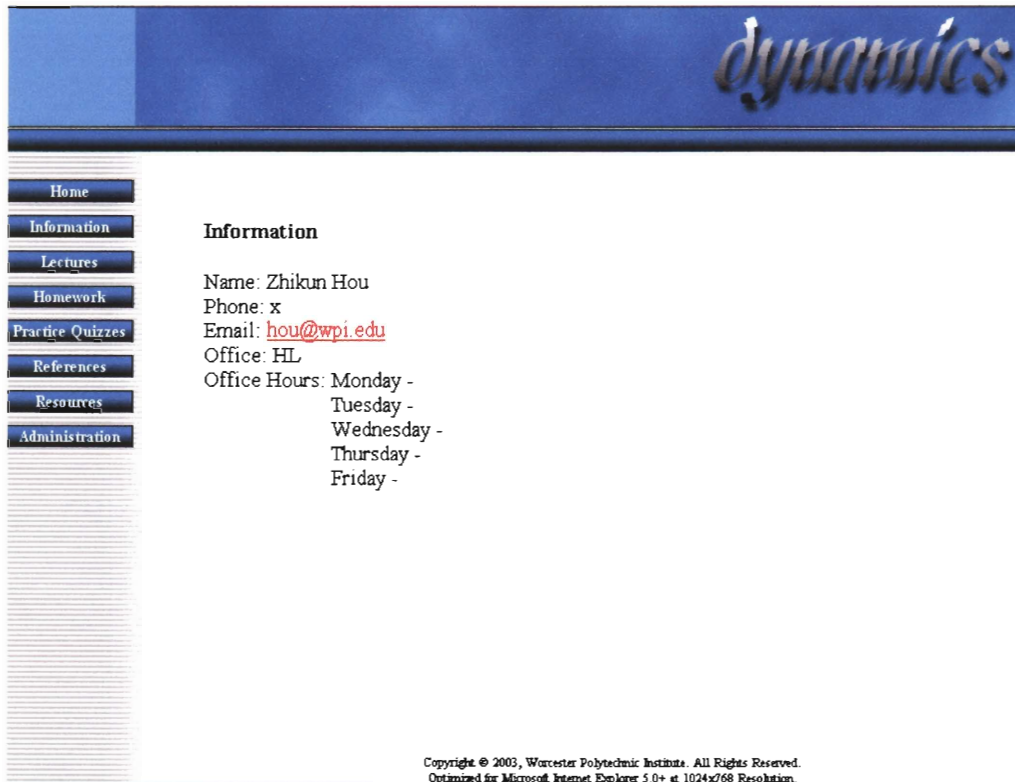


Figure 2: Information Page

The first option on the navigation bar will bring the visitor this page. This page will provide the most basic of the course-related information. It will include the instructor's contact information (shown), the contact information for any course TA's, the instructor's course description, and the course syllabus. This page will be regularly (at the beginning of each term in which the course is taught) updated by either the instructor, the course TA, or any project team that is currently assigned to the site.

3. The Lectures Page

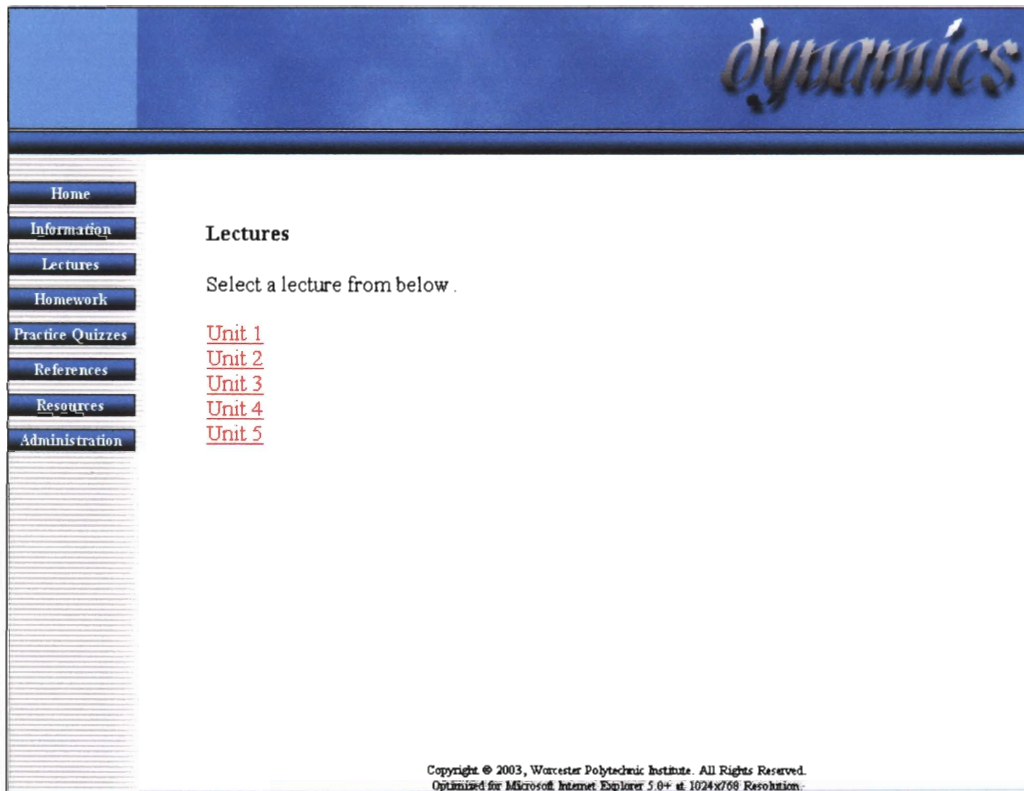


Figure 3: Lectures Page

The Lectures page contains links to each of the topics taught in the course. Currently, the majority of the links are defined by unit number but in the future they should be designated by the topic name for ease of use by the site viewer. These links bring the viewer to a page that contains links to all lecture and project-provided notes for that particular topic/unit.

4. The Sub-Lecture Pages

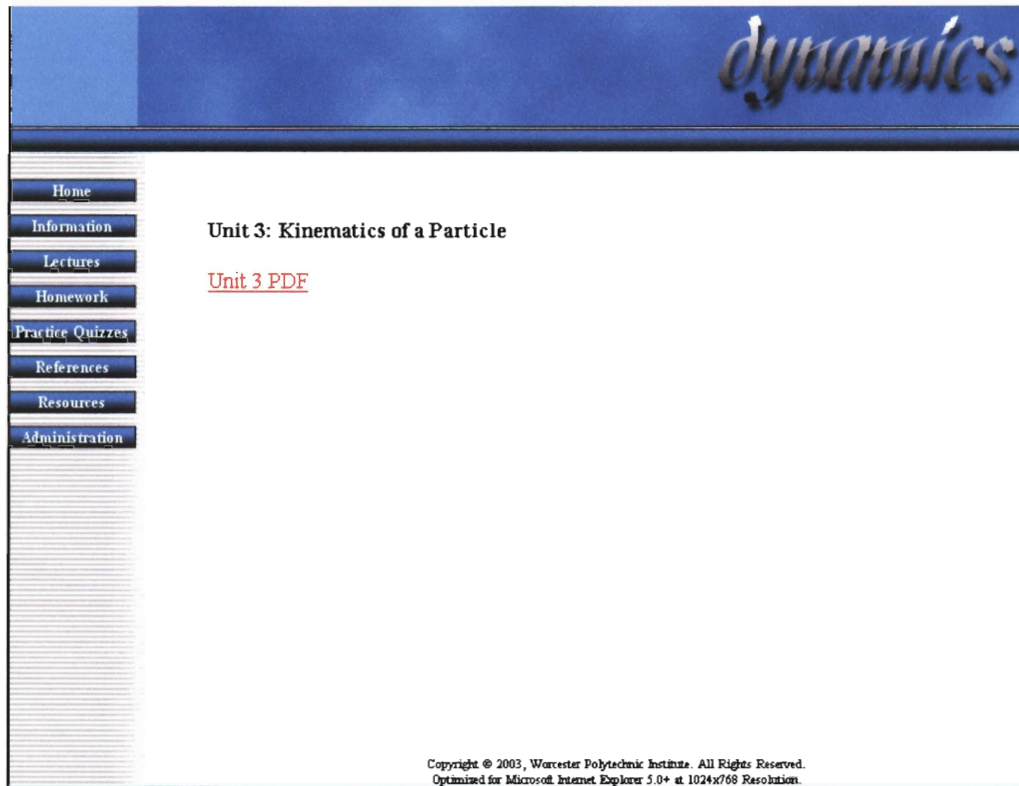


Figure 4: Unit 3 Sub-Lecture Page

The Sub-Lecture pages contain a list of links to all lecture notes, project-provided notes, and practice problems associated with each topic. From this page the viewer can access all the information provided by the site for each of the topic covered. The above page needs more links added to it (the current link leads to the lecture notes provided by the instructor) but the basic idea and format is in place.

5. The Sub-Unit Page

dynamics

Practice Problem #1

Home

Information

Lectures

Homework

Practice Quizzes

References

Resources

Administration

Ball B rotates about 0.5 m about an axis attached by a rod of negligible mass. Ball B has a mass of 10 kg and is subjected to a Moment ($M = (2t^2 + 4) \text{ N m}$). Find the speed after 2 seconds. Ball B has an initial velocity of 2 m/s.

To solve this problem, let's first write down our known information.
 Ball B mass = 10 kg
 Torque = $M = (2t^2 + 4) \text{ N m}$
 Ball has $v_0 = 2 \text{ m/s}$ when $t_0 = 0 \text{ sec}$
 Distance = 0.5 m

Next we use our equation: Principle of Angular Impulse and Momentum

$$(H_0)_1 + \sum \int_1^2 M_x dt = (H_0)_2$$

Recall that the Angular Momentum about point "O" is
 $(H_0)_1 = r_x \times m \cdot v_x = (d) \times (mv) = (0.5 \text{ m})(10 \text{ kg})(2 \text{ m/s}) = 10 \text{ kg m}^2/\text{s}$

Next we evaluate our Angular Impulse

$$\sum \int_1^2 M_x dt = \int_0^2 (2t^2 + 4) dt = 13.33$$

Figure 5: Sample Problem Page

The above page depicts one of the practice problems that were developed by the group. Following a link from the Sub-Lecture page, the viewer is brought to one of practice problems that are provided by the site for each topic of instruction. Each topic covered should have two to four practice problems, depending on the size of the topic, and these problems should vary in complexity. The first problem should be very simple, just the basic application of the fundamentals being taught. The last problem should fully encapsulate all the concepts and possibilities presented by the topic. Any intermediate problems should be used to cover any special cases or just as an example of a mid-level difficulty problem.

6. The Homework Page

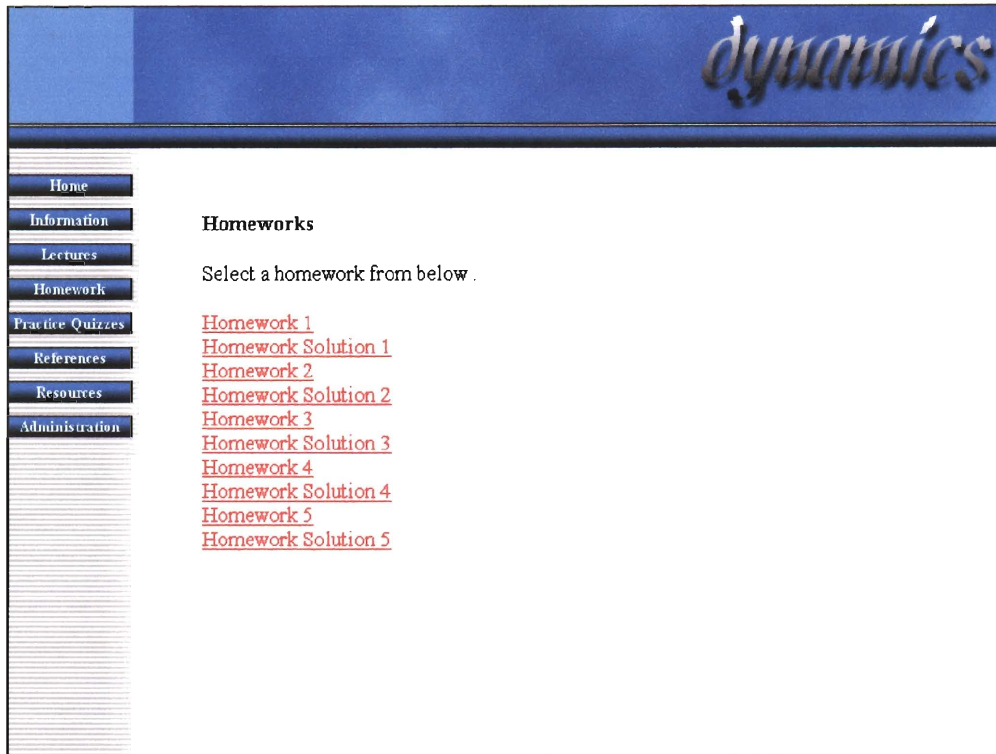


Figure 6: Main Homework Page

The homework portion of the site will be the most updated page of the site during any term that the course is offered. The idea behind this page was to present the homework assignments online so that students in the class could have access to them at any time and so that they could review the solutions without having to visit the instructor or any TA's. The only catch is that the solution sets cannot be put online until after the absolute last day to turn in the assignment. This may mean that the instructor may have to change their existing protocol in terms of students handing in late assignments for the overall benefit of the course population.

7. The Practice Quizzes Page

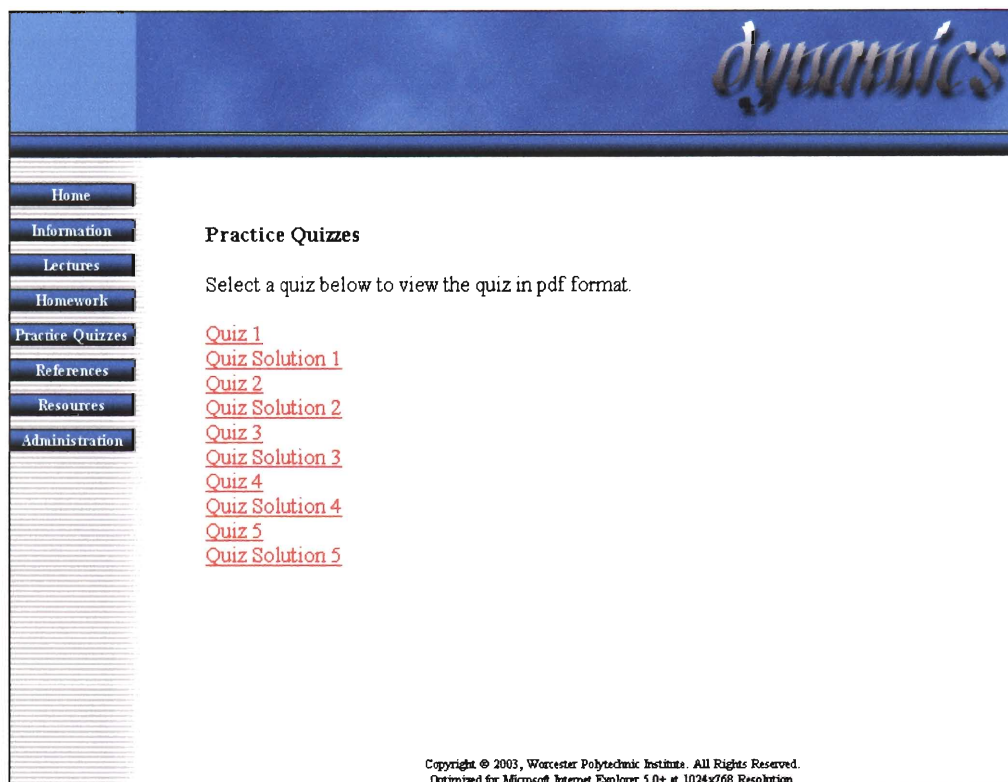
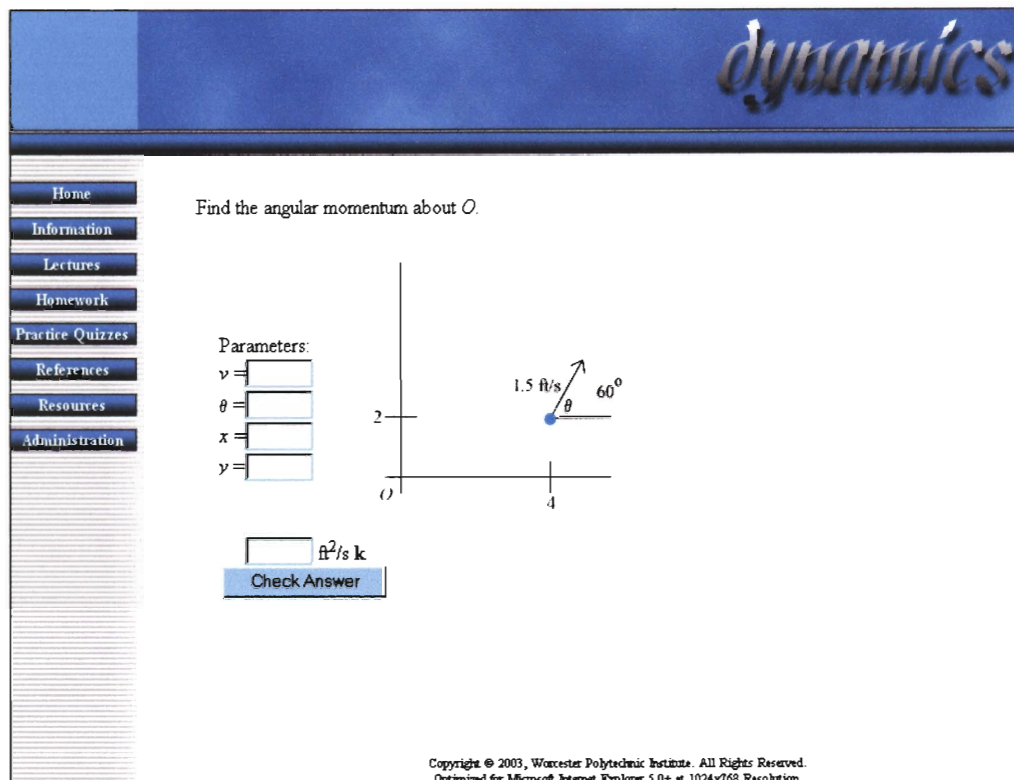


Figure 7: Main Quiz Page

The fifth choice on the navigation bar brings the viewer to the main Practice Quizzes page. The online quizzes were kept to a minimum difficulty level. The majority of the quizzes tested a student's basic understanding of the concepts that were taught in lecture. Once a student understands these fundamental concepts then he/she can apply this knowledge to any dynamics problem that may arise. Most students would not spend the time to solve a comprehensive examination online. Instead, the short quizzes on the site can show a student their weaknesses or strengths in a particular topic. Note: the above links should be labeled according to the content of the quiz so that the viewer will be able to reach their desired destination with all possible celerity.

8. The Sub-Quiz Page



Find the angular momentum about O .

Parameters:

$v =$

$\theta =$

$x =$

$y =$

$\text{ft}^2/\text{s } k$

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Optimized for Microsoft Internet Explorer 5.0+ at 1024x768 Resolution.

Figure 8: Simple Quiz Example

Above is very simple quiz that was designed by the project group. Some initial parameters are set and are accompanied by the diagram to the right of the input boxes. This is just the beginning though because the viewer can input any parameters that they wish and are still able to check to see if they did the problem correctly. This is accomplished by a script that is running in the background of the page that takes the input variables that are typed into the parameter boxes and runs them through the dynamics equation that the viewer would use to obtain the correct answer. This allows this simple quiz to be modified an infinite number of times and the viewer to retry this type of problem as many times as it takes for them to become comfortable with it.

9. The References Page

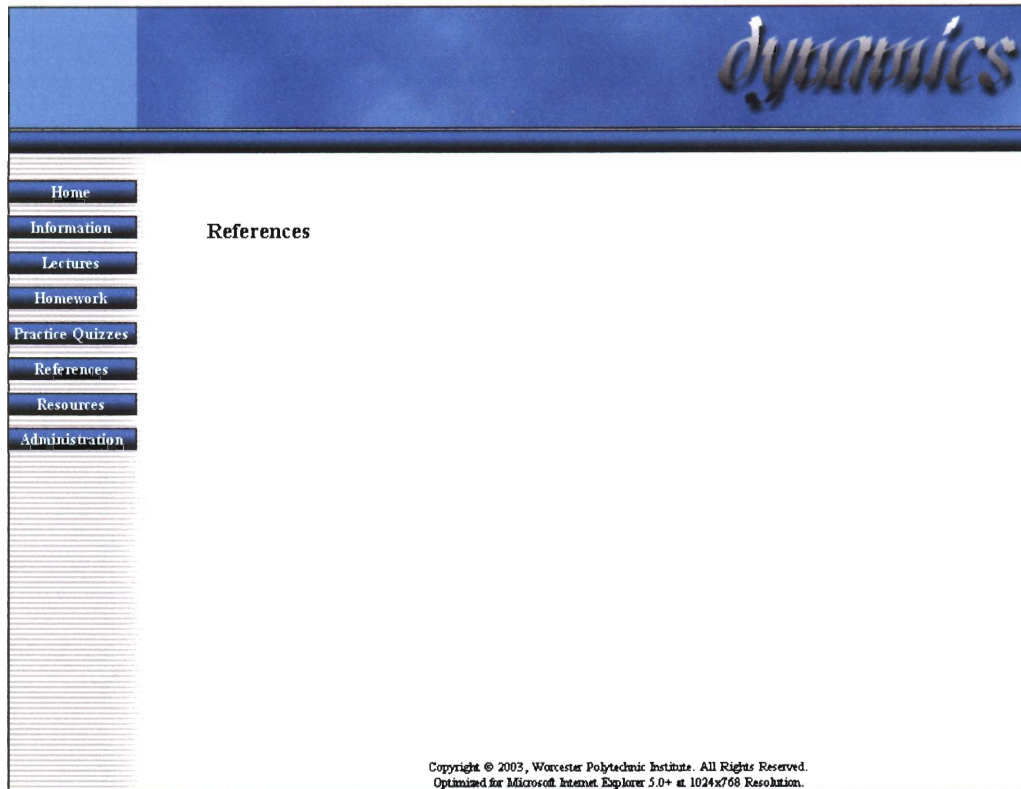


Figure 9: Unfinished References Page

This unfinished page was originally designed by the group to hold a basic glossary of terms used within the site for quick location and review by the viewer. Also, a link to a page that contains a list of equations and the proper circumstances of use was another idea for content on this page brought up by the project group. Any other ideas that future project teams come with would only improve this particular page of the site because it did not receive the full attention of the current group.

10. The Resources Page

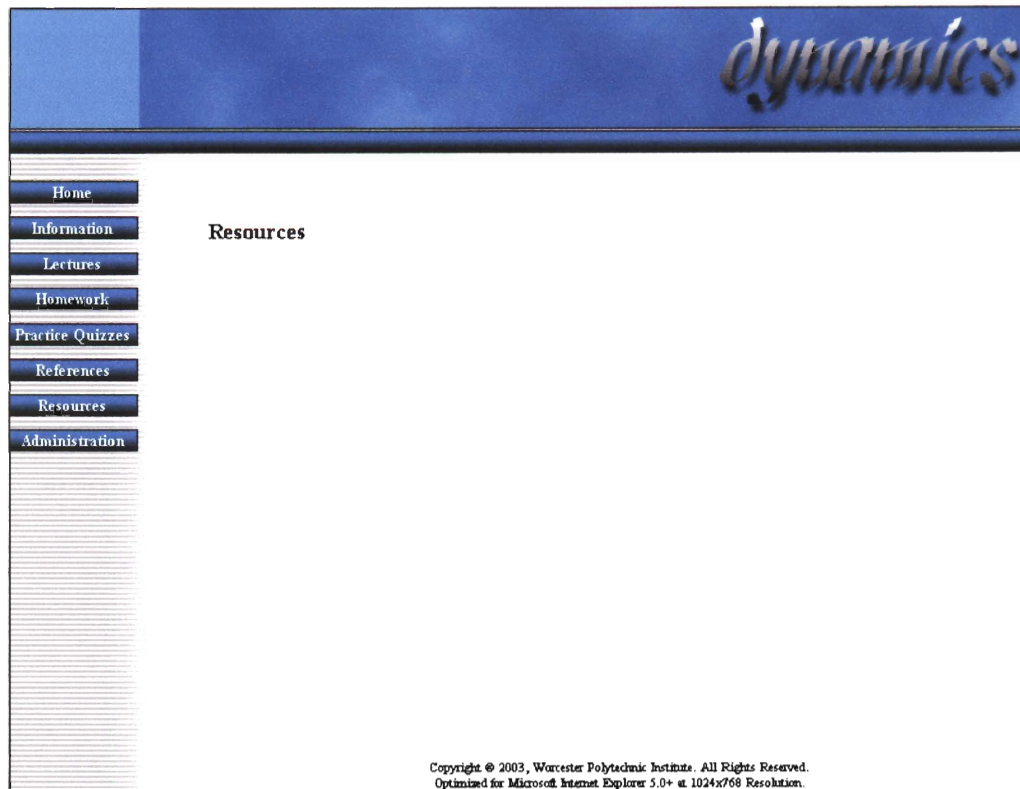


Figure 10: Unfinished Resources Page

This is another page that was in the original concept of the current project group that did not have its content completed. The original design called for a list of links to external sites that might be of extra use to the viewer of this site. Possible sites to link to would be other Dynamics websites, the course textbook publisher's homepage, and other pages within the Worcester Polytechnic Institute community.

11. The Administrator Login Page

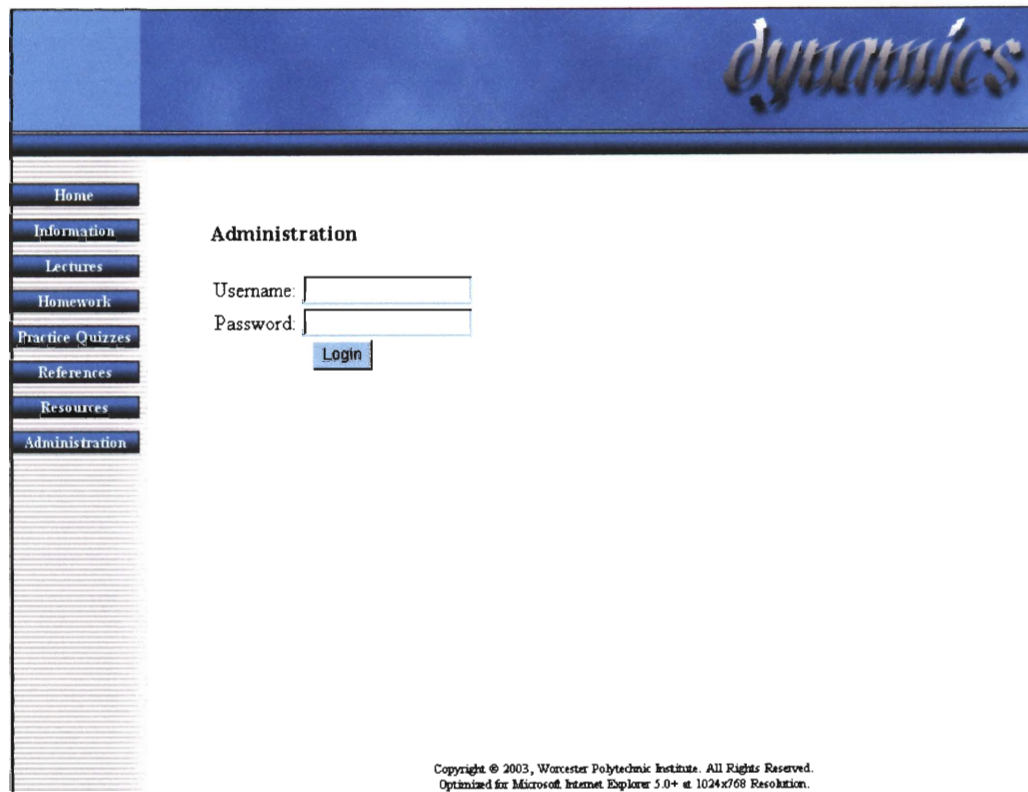


Figure 11: Administrator Login Page

This page is the last choice on the navigation bar specifically because it is a limited access area of the site. Only the course instructor, a course TA, or a member of the latest project team should have access to pages that are linked to this one. To insure that that is the case, a username and password must be supplied to obtain access beyond this point. This area of the site was provided to reduce the difficulty in changing or updating the site in the most common ways. From here it is possible for anyone with access to change or add to the contact information, the files available on the site, and the naming schemes applied to each section. This will make updating/changing the site faster and less complicated for anyone who might not be fully acquainted with web design.

By creating an aesthetically pleasing page with illustrations and multimedia the group hoped to create interest in dynamics. It is quite boring to read black text off a white computer screen and reading the textbook would accomplish the same result. By minimizing the derivations of formulas on the site, it then becomes a tool to help understand dynamics by giving an overview and not an in-depth explanation. The instructor who teaches dynamics should be providing the student with this in-depth explanation during lecture time. Thus, the site becomes a tool for the instructor to aid in their teaching and not a replacement for lecture time.

Appendix B contains three different formats for class lecture notes, the group did not decide on which to use because they all have their positives and negatives. The MSWord format takes a large amount of time and producing the diagrams is difficult. The AutoCAD format takes a large amount of time and producing the equations is difficult. The handwritten format is the fastest of the three but lacks aesthetic qualities of the other two. The eventual conversion of all of the lecture notes to a digital format should be a goal of future project teams, as the notes are of particular importance to effectiveness of the site.

For further reference on the format of the site Appendices B-E will be of help, as well as the actual site itself. The site is currently hosted at the URL:

<http://users.wpi.edu/~bds13/wpidynamics>

And will be available in the future at the URL:

<http://www.wpi.edu/~hou/ES2503>

5 Conclusions

The information gathered and applied during this project has led to beginning of a potentially powerful learning tool. By initiating this project and laying the groundwork for it, the group has made it possible for future project groups to add their own influence to the way the dynamics course is taught at Worcester Polytechnic Institute.

The group did little more than set up the basic package in which the extra information will be delivered but that does not mean that the group did not accomplish anything. To begin with, the group dedicated a vast amount of time to researching sources in an effort to come up with a plan for their site design. This base research will save any future teams from having to do the same work. It effectively shifts the origin of the next project related to this topic ahead by removing most of the guesswork involved in starting a new project.

The group was able to produce a basic framework for the site. This means that there is a kind of template that can be followed for each unfinished section of the site. By including one of the course topics (angular momentum) on the site, the group has provided a working example of its conceptual ideas.

In addition to completing a one of the course topics, the group was also able to make provisions to have the instructors class notes posted on the site as well. This will allow the site to be of some use to the students that are in the course the next time it is offered (D03). The students will also be able to provide

feedback to the instructor about the helpfulness and usability of the site that can be used by future project groups.

As this project achieved its objectives without completing the entire website, there is plenty of work left that can be done by subsequent IQP project groups. The most important work left to be done is the completion of the course topics in terms of posting them onto the website. Work can also be done in the area of quality assessment (i.e. surveys of student who use the site) and, since technology is always changing, constant upgrading of the site. By having additional groups assigned to this project, the current group's initial vision of providing a helpful course supplement will eventually be realized.

On the whole, this project was successful in completing the goals that were set by the group and by the advisor. The site design, a basic template, a simple example, and the addition of external materials were all addressed and completed in a timely manner. The site is online, functioning, and contains enough information to be of use (albeit in an untested state). In conclusion, this project provided the group with the opportunity to produce something that will be helpful to both their community and future communities at Worcester Polytechnic Institute.

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Appendix A: Reference Sites

The following websites were the major sources used for the conceptual work of site layout and design done by the group.

<http://www.sciencejoywagon.com/physicszone/lesson/06moment/default.htm>

The Science Joy Wagon website was a page developed to help students learn physics using online multimedia. The online lectures were quite well put together with plenty of graphical illustration and equations kept to a minimum. The lectures were not overboard with theory and derivations were at a minimum. Occasionally a slideshow was used for an explanation or as an example. The problems online could get deep into theory and really test a students knowledge, but the quizzes were designed to test basic concepts.

<http://www.physics.uoguelph.ca/tutorials/torque/Q.torque.quiz.one.html>

This physics web page was very nicely done. As mentioned above, the instructional modules were put together quite nicely with illustrations and examples. This page has a lot of good qualities that the Science Joy Wagon page also had.

<http://web.umn.edu/~bestdyn/example2.html>

This is a program written to graphically show the vector mechanics of dynamic systems. While this is a program that must be bought, we thought we would include it into our references for it's illustrative purposes.

Appendix B-1: Examples of Unit Lecture Notes in Different Formats

The following lecture notes for ES2503 have been reproduced in the MSWord format.

Unit 1: Introduction

Why do we need to Study Dynamics?

-Dynamic environment and moving objects.



Cars: Impact and Collisions



Airplane: Acceleration, Aerodynamics



Building: Wind, Earthquake

Dynamic effects are sometimes considered with a Safety Factor (SF), but SF approach doesn't always solve the issue.

- Conservative SF increases cost
- Fundamentally new phenomena: Dynamic stability, Resonance
- Critical structures: Analysis for appropriate nuclear power plant design

Relationship between Statics and Dynamics.

-Statics is a special case of Dynamics.

$$\sum \mathbf{F}_i = \mathbf{F} = m\mathbf{a} \quad \text{For Statics } \mathbf{a} = 0 \text{ / For Dynamics } \mathbf{a} \text{ is not zero.}$$

Dynamics can be treated as statics in 4-D space based on D'Alembert's Principle.

$$\begin{aligned} \sum \mathbf{F}_i &= \mathbf{F} = m\mathbf{a} \quad (\text{Newton's 2}^{\text{nd}} \text{ Law}) \\ &= \sum \mathbf{F}_i = \mathbf{F} = (-m\mathbf{a}) \quad (\text{Introduce concept of inertia force}) \\ &= \sum \mathbf{F}_i = \mathbf{F}_I \quad (\text{D'Alembert's Principle}) \end{aligned}$$

When $\sum \mathbf{F}_i = 0$ (Statics) \rightarrow Algebraic equations

When $\sum \mathbf{F}_i = m\mathbf{a}$ (Dynamics) \rightarrow ODE's Mathematical complexity in Dynamics.

Unit Systems: Special attention should be paid for the units used.

	<u>Basic Units</u>	<u>Derived Units</u>	<u>Gravity</u>
(FPS) English System	Force (lb) Length (ft) Time (s)	Mass (slug)	$g = 32.2 \text{ ft} / \text{s}^2$
(SI) International System	Mass (lb) Length (m) Time (s)	Force (N)	$g = 9.8 \text{ m} / \text{s}^2$

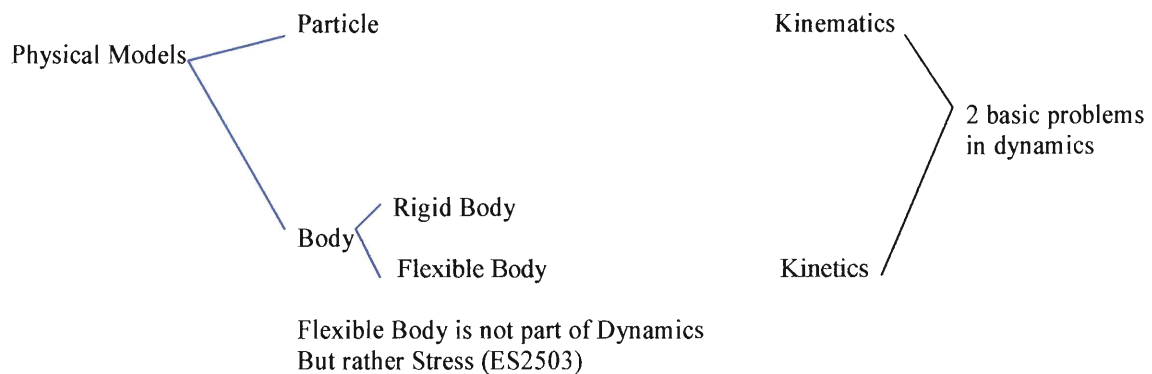
Basic Physical Laws used in Dynamics

-Newton's Law of Motion. 1st Law: a particle originally at rest or moving in a straight line with a constant velocity will remain in this state provided the particle is not subjected to an unbalanced force.

-2nd Law: a particle acted upon by an unbalanced force **F** experiences an acceleration **a** which has the same direction as the force and a magnitude that is directly proportional to the force.

-3rd Law: The mutual forces of action and reaction between two particles is equal, opposite, and collinear.

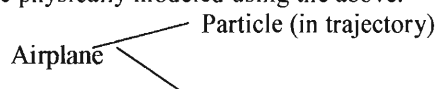
Basic Contents of Dynamics



Physical Models

- Particle → point mass, size effects ignored
- Body → distributed mass over a volume. Size effects are important
- Rigid Body → distance between any two points in body does

Dynamics problems can be physically modeled using the above.



Flexible body (in design)

Coordinate Systems: Cartesian (rectangular) system $\mathbf{r} = x\mathbf{i} + y\mathbf{j} + z\mathbf{k}$
Cylindrical System $\mathbf{r} = r + \Theta$
Spherical System $\mathbf{r} = r + \Theta + z$
Natural System (2d only) \rightarrow tangential and normal systems

Course Description:

This course deals with the kinematics and dynamics of particles and rigid bodies which move in a plane.

Topics covered include:

- Kinematics of particles and Rigid Bodies
- Equations of Motion
- Work Energy methods
- Impulse and Momentum
- Introduction to Mechanical Vibrations
- Basic equations in translating and rotating coordinates.

Appendix B-2: Examples of Unit Lecture Notes in Different Format

The following lecture notes for ES2503 have been reproduced in handwriting and then converted to the .PDF (Adobe Acrobat) format.

unit 3

Page 1

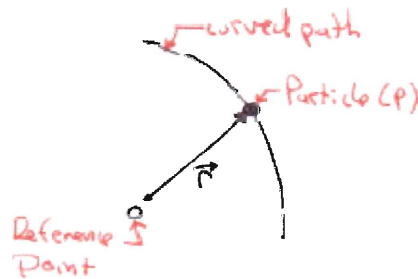
* Kinematics of a particle

1.) Kinematics of a particle in Curvilinear Motion:

Particle moves along a curved path. (Rectilinear is a special case.)

General Vector Form

Position: $\vec{r}(t)$

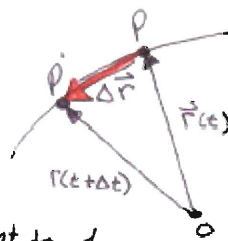


$$\text{Velocity: } \vec{v}_{\text{avg}} = \frac{\Delta \vec{r}}{\Delta t}$$

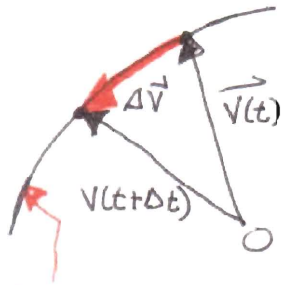
instantaneous velocity:

$$\vec{v}(t) = \lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{r}(t)}{\Delta t} = \frac{d\vec{r}(t)}{dt}$$

tangent to the path



Acceleration: $\vec{a}_{avg} = \frac{\Delta \vec{v}}{\Delta t}$



instantaneous acceleration:

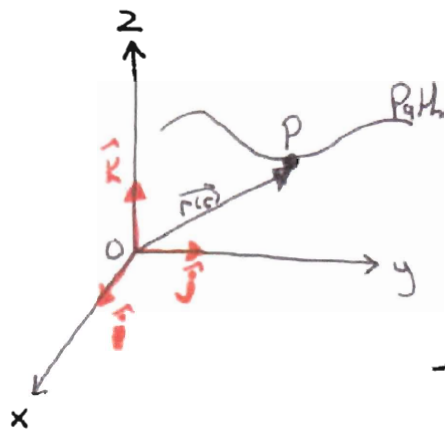
$$\vec{a}(t) = \lim_{\Delta t \rightarrow 0} \frac{\Delta \vec{v}(t)}{\Delta t} = \frac{d\vec{v}(t)}{dt} \text{ tangent to hodograph}$$

* Comments

- $\vec{a}(t)$ is tangent to the hodograph, not the motion.
- In curvilinear motion case, direction of $\vec{r}(t)$, $\vec{v}(t)$, & $\vec{a}(t)$ are important!
- $\vec{r}(t)$, $\vec{v}(t)$, $\vec{a}(t)$ are vectors.
Vector = magnitude & direction. Vector analysis is helpful.
- To describe $\vec{r}(t)$, $\vec{v}(t)$, $\vec{a}(t)$, an appropriate coordinate system should be chosen.

(Cartesian)

2.) Curvilinear motion in a Rectangular Coordinates.



$\hat{i}, \hat{j}, \hat{k}$ = unit vectors in direction of coordinates.
unit vector \rightarrow magnitude = 1

- position: $\vec{r}(t) = x(t)\hat{i} + y(t)\hat{j} + z(t)\hat{k}$

$x(t), y(t), z(t) \rightarrow$ components of the motion.

$|\vec{r}| = \sqrt{x^2 + y^2 + z^2} \rightarrow$ magnitude of $\vec{r}(t)$
distance \overline{OP}

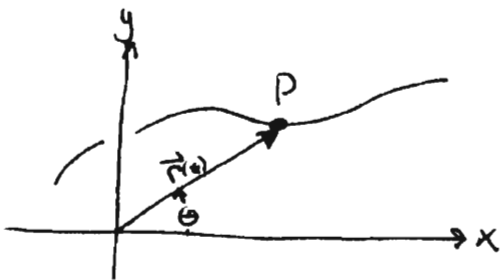
$$\cos \theta_x = \frac{x}{|\vec{r}|}$$

$$\cos \theta_y = \frac{y}{|\vec{r}|}$$

$$\cos \theta_z = \frac{z}{|\vec{r}|}$$

- direction cosines

Special Case for 2-D



$$\vec{r}(t) = x(t)\hat{i} + y(t)\hat{j}$$

$$|\vec{r}| = \sqrt{x^2 + y^2}$$

$$\theta_x = \theta, \quad \theta_y = \frac{\pi}{2} - \theta_x$$

$$\cos \theta_x = \frac{x}{|\vec{r}|} = \cos \theta$$

$$\cos \theta_y = \frac{y}{|\vec{r}|} = \sin \theta$$

- Velocity:

$$\vec{v}(t) = \frac{d\vec{r}}{dt} = \frac{dx}{dt} \hat{i} + \frac{dy}{dt} \hat{j} + \frac{dz}{dt} \hat{k}$$

$$= \boxed{V_x \hat{i} + V_y \hat{j} + V_z \hat{k}}$$

$$\vec{v} = \frac{d}{dt} (x\hat{i} + y\hat{j} + z\hat{k}) = \frac{d}{dt} (x\hat{i}) + \frac{d}{dt} (y\hat{j}) + \frac{d}{dt} (z\hat{k})$$

$$= \frac{dx}{dt} \hat{i} + \frac{dy}{dt} \hat{j} + \frac{dz}{dt} \hat{k} \longrightarrow \boxed{\dot{x} \hat{i} + \dot{y} \hat{j} + \dot{z} \hat{k}}$$

- Acceleration:

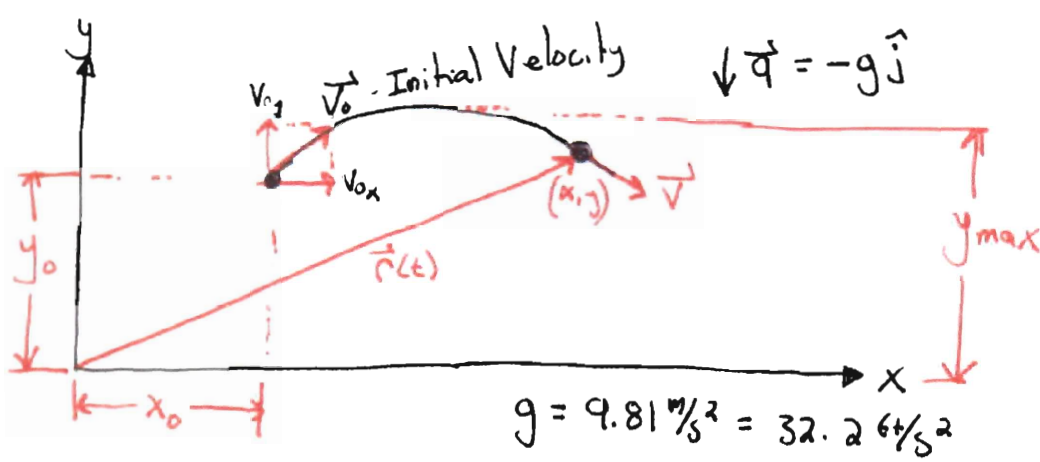
$$\vec{a}(t) = \frac{d\vec{v}}{dt} = \frac{dV_x}{dt} \hat{i} + \frac{dV_y}{dt} \hat{j} + \frac{dV_z}{dt} \hat{k}$$

$$= \frac{d^2x}{dt^2} \hat{i} + \frac{d^2y}{dt^2} \hat{j} + \frac{d^2z}{dt^2} \hat{k} = \boxed{\ddot{x} \hat{i} + \ddot{y} \hat{j} + \ddot{z} \hat{k}}$$

Comments:

- Convenience of Cartesian Vector expressions is from the fact that unit coordinate vectors $\hat{i}, \hat{j}, \hat{k}$ are constant.

3. Case Study: Motion of a Projectile



Given: y_0, \vec{v}_0, \vec{a}

- Find
- Trajectory height (y_{max})
 - Touchdown velocity etc...

$$\vec{r}(t) = \underbrace{x(t)\hat{i}}_{\text{Horizontal motion}} + \underbrace{y(t)\hat{j}}_{\text{Vertical motion}}$$

Horizontal motion: $a_x = 0$
 $\Rightarrow v_x = v_{0x}$
 $x = x_0 + v_{0x}t$

Vertical motion: $a_y = -g$
 $\Rightarrow v_y = v_{0y} - gt$
 $y = y_0 + v_{0y}t - \frac{1}{2}gt^2$
 $v_y^2 - v_{0y}^2 = -2g(y - y_0)$

Derived from general eqn's for constant acceleration

$$v = v_0 + at$$

$$s = s_0 + v_0t + \frac{1}{2}at^2$$

$$v^2 - v_0^2 = 2a(s - s_0)$$

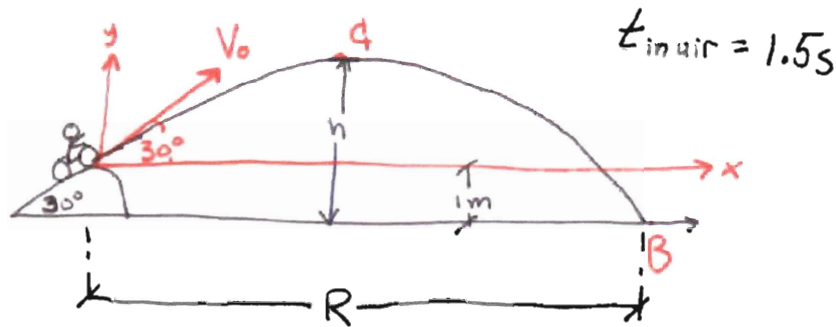
$$y_{max} = y_0 + \frac{1}{2} \frac{v_{0y}^2}{g}$$

* Note: only 2 are independent.

- motions in x & y directions associated by time.

- Four unknowns could be solved by these eqn's.

Example



Find: V_0 = initial Speed

R = horizontal distance he travels before striking ground.

h = max height

Solution: neglect the size of bike & rider (Treat as a particle)

$$V_{0x} = V_0 \cos 30^\circ = \frac{\sqrt{3}}{2} V_0$$

$$V_{0y} = V_0 \sin 30^\circ = \frac{1}{2} V_0$$

In Vertical direction: $y = y_0 + V_{0y}t - \frac{1}{2}gt^2$

$$\downarrow y = -1\text{m} \quad y_0 = 0 \quad V_{0y} = \frac{1}{2}V_0 \quad g = 9.81 \text{ m/s}^2 \quad t = 1.5\text{s}$$

$$-1 = \frac{1}{2}V_0(1.5) - \frac{1}{2}(9.81)(1.5)^2$$

$$\boxed{V_0 = 13.38 \frac{\text{m}}{\text{s}}}$$

Horizontal Direction:

$$x = x_0 + v_{0x} t$$

$$x_0 = 0 \quad v_{0x} = 13.38 \cos 30^\circ \quad t = 1.5 \quad x = R$$

$$\boxed{R = 17.4 \text{ m}}$$

At max height: $v_y = 0$

$$v_y^2 - v_{0y}^2 = -2g(h-1) \rightarrow h = \frac{v_{0y}^2}{2g} + 1 = \frac{(13.38 \sin 30^\circ)^2}{2(9.81)} = \boxed{3.28 \text{ m}}$$

Velocity @ impact

$$v_{0x} = v_{Bx} = v_0 \cos 30^\circ = (13.38) \left(\frac{\sqrt{3}}{2} \right) = 11.6 \text{ m/s}$$

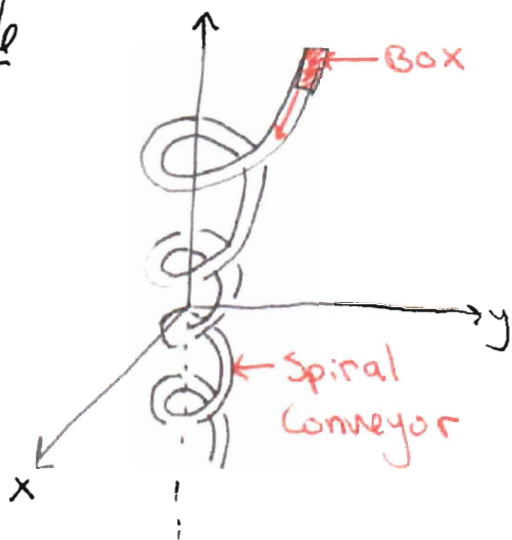
$$v_{By} = v_{0y} t - \frac{1}{2} g t^2 = \frac{13.38}{2} (1.5) - \frac{1}{2} (9.81) (1.5)^2 = 8.02 \text{ m/s}$$

$$v_B = \sqrt{v_{Bx}^2 + v_{By}^2} = \sqrt{11.6^2 + 8.02^2} = \boxed{14.1 \frac{\text{m}}{\text{s}}}$$

or Energy Conservation provides same Result!

$$\frac{1}{2} m v_0^2 + mgh = \frac{1}{2} m v^2 \Rightarrow v_B = \sqrt{2(9.81)(1) + \frac{1}{2}(13.38)^2} \\ = \boxed{14.1 \frac{\text{m}}{\text{s}}}$$

Example



$$\vec{r}(t) = 0.5 \sin 2t \hat{i} + 0.5 \cos 2t \hat{j} - 0.2t \hat{k}$$

Find a.) Location of box @ $t = 0.75s$

b.) magnitude of velocity @ $t = 0.75s$

c.) magnitude of acceleration @ $t = 0.75s$

Solution:

$$\vec{r}(t) = 0.5 \sin 2t \hat{i} + 0.5 \cos 2t \hat{j} - 0.2t \hat{k}$$

$$\vec{v}(t) = \cos 2t \hat{i} - \sin 2t \hat{j} - 0.2 \hat{k}$$

$$\vec{a}(t) = -2 \sin 2t \hat{i} - 2 \cos 2t \hat{j} - 0 \hat{k}$$

\Rightarrow @ $t = 0.75s$

$$a.) \vec{r} = 0.5 \sin 1.5 \hat{i} + 0.5 \cos 1.5 \hat{j} - 0.15 \hat{k}$$

in Radians

$$= 0.449 \hat{i} + 0.354 \hat{j} - 0.15 \hat{k}$$

$$|\vec{r}| = \sqrt{0.449^2 + 0.354^2 + 0.15^2} = \boxed{0.522 \text{ m} = |\vec{r}|}$$

$$\vec{u}_r = \frac{\vec{r}}{|\vec{r}|} = 0.955 \hat{i} + 0.678 \hat{j} + (-0.287 \hat{k}) \quad \text{- direction}$$

$$\theta_x = \cos^{-1}(0.955) = 17.2^\circ$$

$$\theta_y = \cos^{-1}(0.678) = 86.1^\circ$$

$$\theta_z = \cos^{-1}(-0.287) = 107^\circ$$

$$b.) \vec{v}(t) = \cos 1.5t \hat{i} - \sin 1.5t \hat{j} - 0.2t \hat{k}$$

$$\text{magnitude } |\vec{v}| = \sqrt{(\cos 1.5)^2 - (\sin 1.5)^2 + (-0.2)^2} = 1.02 \text{ m/s}$$

$$c.) \vec{v}(t) = -2 \sin 2t \hat{i} - 2 \cos 2t \hat{j}$$

$$\Rightarrow \text{magnitude } a = \sqrt{(-2 \sin 2t)^2 + (-2 \cos 2t)^2} = 2 \text{ m/s}^2$$

- If using cylindrical System:

$$\vec{r}(t) = 0.5 \sin 2t \hat{i} + 0.5 \cos 2t \hat{j} - 0.2t \hat{k}$$

$$\downarrow \rho = 0.5 \quad \theta(t) = 2t \quad \dot{\theta} = 2$$

$$r(t) = 0.5 \vec{U}_r - 0.2t \hat{k}$$

$$\downarrow \dot{\rho} = 0 \quad \dot{\theta} = 2$$

$$\ddot{\rho} = 0 \quad \ddot{\theta} = 0$$

$$\vec{v}(t) = \dot{\rho} \vec{U}_r + 0.5 \dot{\theta} \vec{U}_\theta - 0.2 \hat{k}$$

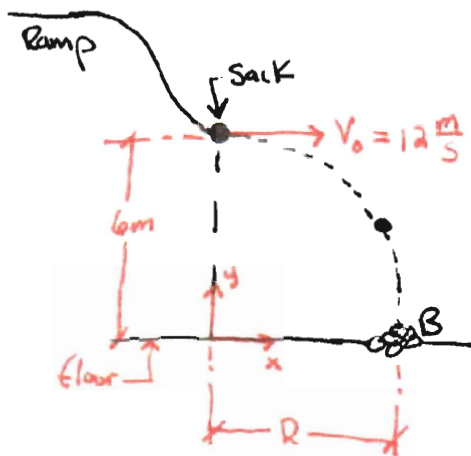
$$= \vec{U}_\theta - 0.2 \hat{k} \Rightarrow |\vec{v}| = \sqrt{1^2 + (0.2)^2} = 1.02 \text{ m/s}$$

\(\downarrow\)

$$a(t) = -\dot{\theta} \vec{U}$$

$$\boxed{|a| = 2 \text{ m/s}^2}$$

Example:



Find a.) time needed for the sack to strike the floor.

b.) R — range where sacks begin to p. b. up.

Solution

$$\vec{v}_0 = v_{0x} \hat{i} + v_{0y} \hat{j}$$

$$v_{0x} = 12 \frac{m}{s}$$

$$\vec{a} = -g \hat{j}$$

$$v_{0y} = 0 \frac{m}{s}$$

$$g = 9.81 \frac{m}{s^2}$$

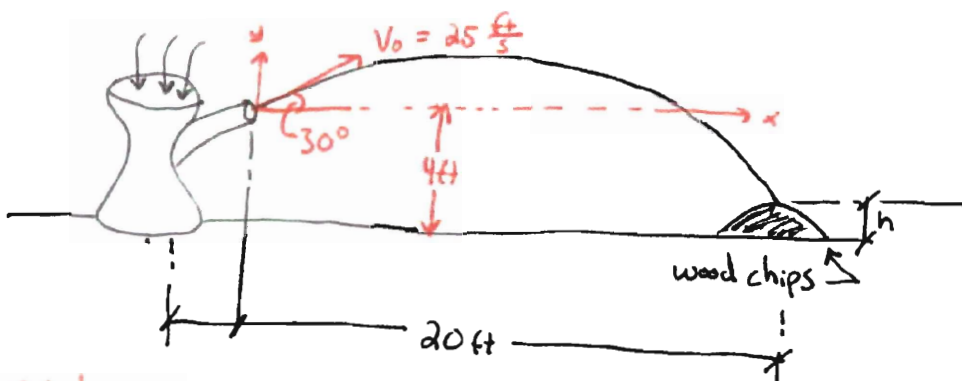
$$\begin{cases} v_x = v_{0x} \\ x = x_0 + v_{0x} t \end{cases} \quad \begin{cases} y = 0 \\ y_0 = 6m \end{cases} \rightarrow 0 = 6 - \frac{1}{2}(9.81)t^2$$

$$\boxed{t = 1.11s}$$

$$\begin{cases} v_y = v_{0y} - gt \\ y = y_0 + v_{0y}t - \frac{1}{2}gt^2 \\ v_y^2 = v_0^2 - 2g(y - y_0) \end{cases} \quad \begin{cases} x_0 = 0 \\ v_{0x} = 12 \frac{m}{s} \end{cases} \quad t = 1.11s$$

$$\boxed{R = 12(1.11) = 13.3m}$$

Example: chipping Machine



Solution:

$$v_{0x} = 25 \cos 30^\circ = 21.65 \frac{ft}{s}$$

$$v_{0y} = 25 \sin 30^\circ = 12.5 \frac{ft}{s}$$

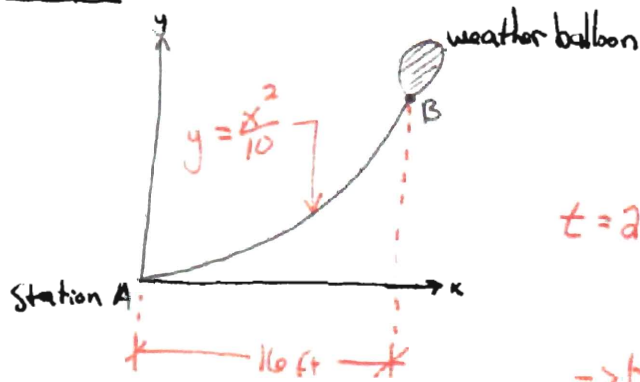
horizontal: $s = s_0 + v_{0x}t \rightarrow \frac{20}{21.65} = \boxed{t = 0.9285}$

Vertical: $h = h_0 + V_{0y}t - \frac{1}{2}gt^2$

$$h = 4 + 12.5(0 - 9.328) - \frac{1}{2}(32.2)(0.9328)^2$$

$$h = 1.81 \text{ ft}$$

Example:



Find a.) distance btw station A & balloon B at $t = 2\text{s}$.

$$t = 2\text{s} \cdot x = 8(2) = 16 \text{ ft}$$

$$y = \frac{16^2}{10} = 25.6 \text{ ft}$$

$$\Rightarrow |r| = \sqrt{x^2 + y^2} = \sqrt{16^2 + 25.6^2} = 30.2 \text{ ft}$$

b.) Velocity @ $t = 2\text{s}$.

$$r(t) = 8t\hat{i} + 6.4t^2\hat{j}$$

$$v(t) = \frac{dr}{dt} = 8\hat{i} + 12.8t\hat{j}$$

$$\text{@ } t = 2\text{s} \quad v_x = 8 \text{ ft/s} \quad v_y = 25.6 \text{ ft/s}$$

$$v = \sqrt{v_x^2 + v_y^2} = \sqrt{8^2 + 25.6^2} = \boxed{26.8 \text{ ft/s}}$$

$$\tan \theta_x = \frac{v_y}{v_x} = \frac{25.6}{8} \Rightarrow \theta_x = \boxed{72.6^\circ}$$

c.) acceleration @ $t = 2\text{s}$.

$$a(t) = \frac{dv}{dt} = 0\hat{i} + 12.8\hat{j} \quad a_x = 0 \quad a_y = 12.8$$

$$\Rightarrow a = 12.8 \text{ ft/s}^2 (\uparrow)$$

$$\theta_a = \tan^{-1} \frac{12.8}{0} = 90^\circ$$

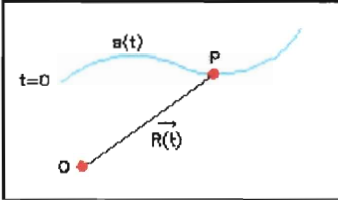
Appendix B-3: Examples of Unit Lecture Notes in Different Formats

The following lecture notes for ES2503 have been reproduced in the AutoCAD format.

Page 1

UNIT 5: Kinematics of a Particle in Curvilinear Motion

1. Introduction



Position Vector $R(\mathbf{s}) =$ moving path of motion, or trajectory

Velocity $\vec{V}(t) = \frac{dR(\mathbf{s})}{dt}$

Acceleration $\vec{A}(t) = \frac{dV(\mathbf{s})}{dt}$

In Rectangular Coordinates

Position Vector $\vec{R}(t) = x(t)\hat{i} + y(t)\hat{j} + z(t)\hat{k}$

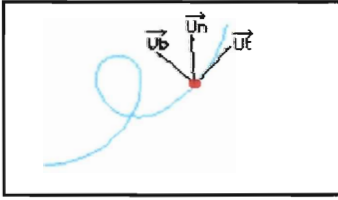
Velocity Vector $\vec{V}(t) = \dot{x}(t)\hat{i} + \dot{y}(t)\hat{j} + \dot{z}(t)\hat{k}$

Acceleration Vector $\vec{A}(t) = \ddot{x}(t)\hat{i} + \ddot{y}(t)\hat{j} + \ddot{z}(t)\hat{k}$

$\hat{i} = \hat{i} = \hat{j} = \text{constant}$ Sometimes we need expressions in other coordinate systems for convenience.

2. Expression in terms (local)

There exists a local orthogonal frame in the neighborhood of any point on a smooth space curve.



$\vec{U}_t =$ Tangent Vector $= d\vec{R}/ds$

$\vec{U}_b =$ Bi-Normal $= \vec{U}_n \times \vec{U}_t$

$\vec{U}_n =$ Principle Normal $= (1/\rho)(d\vec{U}_t/ds) = (1/k)(d^2R/ds^2)$

Differential Relationships between $\vec{U}_t, \vec{U}_b, \vec{U}_n$

$d\vec{U}_t/ds = (k)\vec{U}_n$	$k =$ Curvature
$d\vec{U}_n/ds = (-k)\vec{U}_t = (-v)\vec{U}_b$	$v =$ torsion
$d\vec{U}_b/ds = (v)\vec{U}_n$	$k = 1/\rho$

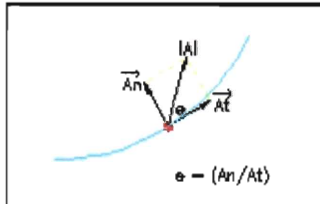
$\rho =$ radius of curvature $\rho = \frac{[1 + (dy/dx)^2]^{3/2}}{|d^2y/dx^2|}$

- Tangent Component $A_t = d^2s/dt^2 = dv/dt$

- Normal Component $A_n = v^2/\rho$

- Magnitude of \vec{A} : $A = \sqrt{A_t^2 + A_n^2}$

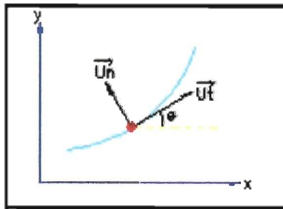
- Direction of \vec{A} on the oscillating plane.



Special Case: \vec{u}
Plane Motion: \vec{u} is a constant vector

Plane Circular Motion: $\rho = R$

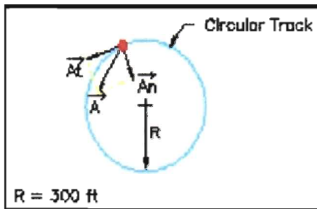
Example: 2-D Six-Flags Curve Ride



$$\vec{u} = \cos(\theta)\hat{i} + \sin(\theta)\hat{j}$$

$$d\vec{u}/ds = (-\sin\theta(d\theta/ds)\hat{i} + \cos\theta(d\theta/ds)\hat{j}) = \underbrace{d\theta/ds}_{\text{magnitude}} \underbrace{(-\sin\theta\hat{i} + \cos\theta\hat{j})}_{\text{direction}}$$





$$\vec{A}_t = 2 \text{ m/s}^2 = \text{constant}$$

Find t needed for $A = 8 \text{ ft/s}^2$ and V at that time.

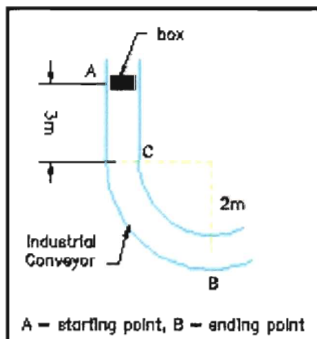
Solution:

$$Vt = V_0 + A_t t = 7t$$

$$A = \sqrt{A_t^2 + A_n^2} = \sqrt{7^2 + (7t/300)^2} = 8$$

$$t = 4.87 \text{ s}$$

$$V \Big|_{4.87 \text{ s}} = (4.28 \text{ s}) = 34.1 \text{ ft/s}$$



Determine AB if $A_t = 0.2t \text{ m/s}^2$

Solution:

$$A_t = \dot{v} = 0.2t \rightarrow v = 0.1t^2$$

$$s_{ACB} = \int_A^B ds = 3t + 1/2(2)(\pi)(2) = 3t\pi = 6.112$$

$$-\int_0^{tB} v dt = (0.1)/3t^3 \rightarrow -6.112 = (0.1/3)t^3 \quad \text{ie. } tB = 5.89 \text{ s}$$

$$A_{tB} = 0.2t = 0.2(5.89) = 1.138 \text{ m/s}^2$$

$$v_B = 0.1t^2 = 0.1(5.89)^2 = 3.238 \text{ m/s}$$

$$A_{nB} = v_B^2 / r_B = 3.238^2 / 2 = 5.242 \text{ m/s}^2$$

$$AB = \sqrt{A_t^2 + A_{nB}^2} = \sqrt{1.138^2 + 5.242^2} = 5.36 \text{ m}$$

Appendix C: Website Documentation

The following is the standard program documentation template provided by the Computer Science Department at Worcester Polytechnic Institute.

Details

Author: Blain D. Smith, Jason Gadebusch, Rob Sweeney, and Samuel Clark

Date: February 10, 2003

Version: 1.0

Project ID: IQP ZWH-0202

Class: IQP ZWH-0202

Programming Language: PHP, HTML, MySQL

Program Description

Overall Design

System Structure

- wpidynamics
 - images
 - background.gif
 - button_background.gif
 - getacrobatreader.gif
 - getflashplayer.gif
 - spacer.gif
 - include
 - functions.php
 - stylesheet.css
 - pdf
 - homework01.pdf
 - homework02.pdf
 - homework03.pdf
 - homework04.pdf
 - homework05.pdf
 - homeworksolution01.pdf
 - homeworksolution02.pdf
 - homeworksolution03.pdf
 - homeworksolution04.pdf
 - homeworksolution05.pdf
 - quiz01.pdf
 - quiz02.pdf
 - quiz03.pdf
 - quiz04.pdf
 - quiz05.pdf
 - quizsolution01.pdf
 - quizsolution02.pdf
 - quizsolution03.pdf

- quizsolution04.pdf
- quizsolution05.pdf
- unit01.pdf
- unit02.pdf
- unit03.pdf
- unit04.pdf
- unit05.pdf
- unit06.pdf
- unit07.pdf
- unit08.pdf
- unit09.pdf
- unit10.pdf
- unit11.pdf
- unit12.pdf
- unit13.pdf
- unit14.pdf
- unit15.pdf
- homeworks.php
- index.php
- information.php
- lectures.php
- practicequizzes.php
- references.php
- resources.php

Data Representation

Data for the homework, quizzes and unit lectures are represented as PDF files. Data for the "Information", "Resources" and "References" sections of the site are saved in a MySQL database.

Program Assumptions and Restrictions

Assume that all users are using a graphical web browser to access this site. The client machine used to view the site has the ability to view PDF files.

Interfaces

User

There is a left "floating" navigational system which will follow the user as they scroll up and down.

Implementation Details

Server

PHP 4.0 enables web server

Database

wpidynamics (MySQL Database)

How to Access the Program

- 1) Open a web browser.
- 2) Type "<http://users.wpi.edu/~bds13/wpidynamics/>" into the location text box and hit **ENTER**.

Appendix D: Website Program Source Code

homeworks.php

```
<?include("include/functions.php");  
$title = "Homeworks";  
Top($title);?>
```

Select a homework from below .


```
<a href="pdf/homework01.pdf">Homework 1</a><br>  
<a href="pdf/homeworksolution01.pdf">Homework Solution  
1</a><br>  
<a href="pdf/homework02.pdf">Homework 2</a><br>  
<a href="pdf/homeworksolution02.pdf">Homework Solution  
2</a><br>  
<a href="pdf/homework03.pdf">Homework 3</a><br>  
<a href="pdf/homeworksolution03.pdf">Homework Solution  
3</a><br>  
<a href="pdf/homework04.pdf">Homework 4</a><br>  
<a href="pdf/homeworksolution04.pdf">Homework Solution  
4</a><br>  
<a href="pdf/homework05.pdf">Homework 5</a><br>  
<a href="pdf/homeworksolution05.pdf">Homework Solution  
5</a><br>  
  
<?Bottom() ?>
```

index.php

```
<?include("include/functions.php");  
$strTitle = "dynamics <b><i>Online!</i></b>";  
Top($strTitle);?>
```

Engineers should be able to formulate and solve problems that involve forces that act on bodies which are moving. This course deals with the kinematics and dynamics of particles and rigid bodies which move in a plane. Topics covered will include: kinematics of particles and rigid bodies, equations of motion, work-energy methods, and impulse and momentum. In this course a basic introduction to mechanical vibration is also discussed. Basic equations will be developed with respect to translating and rotating coordinate systems.

The following software titles are required to view certain aspects of this site:


```
<a
href="http://www.macromedia.com/go/getflashplayerbutton/"
target="new"> Macromedia Flash Player</a><br><br><a
href="http://www.adobe.com/products/acrobat/readstep2.html"
target="new"> Adobe Acrobat Reader</a>
```

```
<?Bottom();?>
```

information.php

```
<?include("include/functions.php");
$title = "Information";
Top($title);

$link = mysql_connect($mysql_host, $mysql_username,
$mysql_password);
mysql_select_db($mysql_database);

$sql = "SELECT tblOfficeHours.* FROM tblOfficeHours ORDER
BY tblOfficeHours.OfficeHoursId";
$result = mysql_query($sql);
if(mysql_num_rows($result) != 0)
{
    while($row = mysql_fetch_assoc($result))
    {?>
        Name: <?echo($row["FirstName"]);?>
<?echo($row["LastName"]);?><br>
        Phone: <?echo($row["PhoneNumber"]);?><br>
        Email: <a
href="mailto:<?echo($row["Email"]);?>"><?echo($row["Email"]
);?></a><br>
        Office: <?echo($row["Office"]);?><br>
        <table border="0" cellpadding="0"
cellspacing="0">
            <tr>
                <td valign="top"><font>Office
Hours:</font></td>
                <td><font>&nbsp;</font></td>
                <td>
                    <font>
<?echo($row["OfficeHours"]);?>
```

```
                </font>
            </td>
        </tr>
    </table>
    <?>
}
```

```
mysql_free_result($result);
mysql_close($link);
```

```
Bottom()??>
```

lectures.php

```
<?include("include/functions.php");
$title = "Lectures";
Top($title);?>
```

Select a lecture from below .


```
<a href="pdf/unit01.pdf">Unit 1</a><br>
<a href="pdf/unit02.pdf">Unit 2</a><br>
<a href="pdf/unit03.pdf">Unit 3</a><br>
<a href="pdf/unit04.pdf">Unit 4</a><br>
<a href="pdf/unit05.pdf">Unit 5</a><br>
<a href="pdf/unit06.pdf">Unit 6</a><br>
<a href="pdf/unit07.pdf">Unit 7</a><br>
<a href="pdf/unit08.pdf">Unit 8</a><br>
<a href="pdf/unit09.pdf">Unit 9</a><br>
<a href="pdf/unit10.pdf">Unit 10</a><br>
<a href="pdf/unit11.pdf">Unit 11</a><br>
<a href="pdf/unit12.pdf">Unit 12</a><br>
<a href="pdf/unit13.pdf">Unit 13</a><br>
<a href="pdf/unit14.pdf">Unit 14</a><br>
<a href="pdf/unit15.pdf">Unit 15</a><br>
```

```
<?Bottom()??>
```

practicequizzes.php

```
<?include("include/functions.php");
$title = "Practice Quizzes";
Top($title);?>
```

Select a quiz from below .


```
<a href="pdf/quiz01.pdf">Quiz 1</a><br>
<a href="pdf/quizsolution01.pdf">Quiz Solution 1</a><br>
<a href="pdf/quiz02.pdf">Quiz 2</a><br>
<a href="pdf/quizsolution02.pdf">Quiz Solution 2</a><br>
<a href="pdf/quiz03.pdf">Quiz 3</a><br>
<a href="pdf/quizsolution03.pdf">Quiz Solution 3</a><br>
<a href="pdf/quiz04.pdf">Quiz 4</a><br>
<a href="pdf/quizsolution04.pdf">Quiz Solution 4</a><br>
<a href="pdf/quiz05.pdf">Quiz 5</a><br>
<a href="pdf/quizsolution05.pdf">Quiz Solution 5</a><br>
```

```
<?Bottom()?>
```

references.php

```
<?include("include/functions.php");
$title = "References";
Top($title);?>
```

Equations Here

```
<?Bottom();?>
```

resources.php

```
<?include("include/functions.php");
$title = "Resources";
Top($title);
```

```
$link = mysql_connect($mysql_host, $mysql_username,
$mysql_password);
mysql_select_db($mysql_database);
```

```
$sql = "SELECT tblResources.* FROM tblResources WHERE
(tblResources.Inactive = 0) ORDER BY tblResources.AddDate";
$result = mysql_query($sql);
if(mysql_num_rows($result) != 0)
```

```

{
    while($row = mysql_fetch_assoc($result))
    {
        <b><?echo($row["Title"]);?></b> (Added:
<?echo($row["AddDate"]);?><br>
        <?echo($row["Description"]);?>
        <?if($row["URL"] != "")
        {
            <br>
            URL: <a href="<?echo($row["URL"]);?>"
target="new"><?echo($row["URL"]);?></a>
            <?}?>
            <br><br>
        }
    }
}

mysql_free_result($result);
mysql_close($link);

Bottom()?>

```

functions.php

```

<?
$mysql_host = "mysql.wpi.edu";
$mysql_username = "bds13";
$mysql_password = "8bCmu3";
$mysql_database = "wpidynamics";

$break = chr(13) & chr(10);
$symbol = "style=\"font-family:Symbol; font-size:17px;\"";
$times_new_roman = "style=\"font-family:Times New Roman;
font-size:26px;\"";
$sigma = "<font {$symbol}>#83;</font>";
$cross = "<font {$symbol}>#180;</font>";
$degree = "<font {$symbol}>#176;</font>";
$integral = "<font {$times_new_roman}>#8747;</font>";
$theta = "<font {$symbol}>#113;</font>";
$doesnotequal = "<font {$symbol}>#185;</font>";
$openinfinity = "<font {$symbol}>#181;</font>";
$congruent = "<font {$symbol}>#64;</font>";
$error_margin = 1;

function Top($title)
{
    session_start();

```



```

header("Cache-control: private");?>
<html>
<head>
<title>dynamics</title>
<link rel="stylesheet" href="include/stylesheet.css"
type="text/css">
</head>
<body bgcolor="#c0c0c0" topmargin="0" leftmargin="0"
link="#ff0000" alink="#ff0000" vlink="#ff0000">

<script>
if(!document.layers)
{
    document.write('<div id="divStayTopLeft"
style="position:absolute; width:100px; top:130px;
left:0px;">');
}
</script>

<layer id="divStayTopLeft">

<!--EDIT BELOW CODE TO YOUR OWN MENU-->
<?DisplayButton("Home", "index.php");
DisplayButton("Information", "information.php");
DisplayButton("Lectures", "lectures.php");
DisplayButton("Homework", "homeworks.php");
DisplayButton("Practice Quizzes",
"practicequizzes.php");
DisplayButton("References", "references.php");
DisplayButton("Resources", "resources.php");

if(!session_is_registered("Administrator"))
{
    DisplayButton("Administration",
"administration.php");
}?>
<!--END OF EDIT-->

</layer>

<script type="text/javascript">

/*
Floating Menu script- Roy Whittle
(http://www.javascript-fx.com/)

```

```

Script featured on/available at
http://www.dynamicdrive.com/
This notice must stay intact for use
*/

//Enter "frombottom" or "fromtop"
var verticalpos="fromtop"

if(!document.layers)
{
    document.write('</div>');
}

function JSFX_FloatTopDiv()
{
    var startX = 0,
        startY = 130;
    var ns = (navigator.appName.indexOf("Netscape")
!= -1);
    var d = document;
    function ml(id)
    {
        var
el=d.getElementById?d.getElementById(id):d.all?d.all[id]:d.
layers[id];
        if(d.layers)el.style=el;

        el.sP=function(x,y){this.style.left=x;this.style.top=y
;};

        el.x = startX;
        if (verticalpos=="fromtop")
            el.y = startY;
        else{
            el.y = ns ? pageYOffset + innerHeight :
document.body.scrollTop + document.body.clientHeight;
            el.y -= startY;
        }
        return el;
    }
    window.stayTopLeft=function()
    {
        if (verticalpos=="fromtop"){
            var pY = ns ? pageYOffset :
document.body.scrollTop;
            ftlObj.y += (pY + startY - ftlObj.y)/8;
        }
        else{

```

```

        var pY = ns ? pageYOffset + innerHeight
: document.body.scrollTop + document.body.clientHeight;
        ftlObj.y += (pY - startY - ftlObj.y)/8;
    }
    ftlObj.sP(ftlObj.x, ftlObj.y);
    setTimeout("stayTopLeft()", 10);
}
ftlObj = ml("divStayTopLeft");
stayTopLeft();
}
JSFX_FloatTopDiv();
</script>

```

```

<table border="0" cellpadding="0" cellspacing="0"
height="100%">
    <tr>
        <td width="1" bgcolor="#000000"></td>
        <td width="800"
background="images/background.gif" valign="top">
            <table border="0" cellpadding="0"
cellspacing="0" width="100%" height="100%">
                <tr>
                    <td align="right"
bgcolor="#7DA7D9" height="1%"></td>
                </tr>
                <tr>
                    <td height="1"
bgcolor="#000000"></td>
                </tr>
                <tr>
                    <td height="1"
bgcolor="#f1f1f1"></td>
                </tr>
                <tr>
                    <td height="1"
bgcolor="#000000"></td>
                </tr>
                <tr>
                    <td height="16" align="right"
bgcolor="#000000"
background="images/button_background.gif"></td>
                </tr>
            </table>
        </td>
    </tr>
</table>

```

```

        <tr>
            <td valign="top">
                <table border="0"
cellpadding="0" cellspacing="0" width="100%" height="100%">
                    <tr>
                        <td
colspan="3" height="50">&nbsp;</td>
                    </tr>
                    <tr>
                        <td
width="150" valign="top">&nbsp;</td>
                        <td
width="5"></td>
                        <td
height="1%"><font><b><?echo($title);?></b></font></td>
                    </tr>
                    <tr>
                        <td
colspan="3" height="1%"></td>
                    </tr>
                    <tr>
                        <td
width="150" valign="top">&nbsp;</td>
                        <td
width="5"></td>
                        <td
valign="top">
                            <table
border="0" cellpadding="0" cellspacing="0" width="100%"
height="100%">
                                <tr>
                                    <td height="99%" valign="top">
                                        <font>
<?>
function Bottom()
{?>
                                        </font>
                                        </td>

```

```

</tr>
<tr>
<td height="50">&nbsp;</td>
</tr>
<tr>
<td align="center" height="1%">
<font style="font-size:10px;">
<br><br>
Copyright &copy; <?echo(date("Y"));?>, Worcester
Polytechnic Institute. All Rights Reserved.<br>
Optimized for Microsoft Internet Explorer 5.0+ at
1024x768 Resolution.
</font>
</td>
</tr>
</table>
</td>
</tr>
</table>
</td>
</tr>
</table>
</td>
<td width="1" bgcolor="#000000"></td>
</td>
</table>
</body>
</html>
<?}
function DisplayButton($caption, $link)
{?}
<table border="0" cellpadding="0" cellspacing="0"
width="100%">

```

```

        <tr>
            <td height="1" bgcolor="#000000"
colspan="3"></td>
        </tr>
        <tr>
            <td width="1" bgcolor="#000000"></td>
            <td bgcolor="#AAC6E6"
background="images/button_background.gif" align="center"><a
href="<?echo($link);?>" style="font-weight:bold; font-
size:12px; text-decoration:none;
color:#ffffff;"><?echo($caption);?></a></td>
            <td width="1" bgcolor="#000000"></td>
        </tr>
        <tr>
            <td height="1" bgcolor="#000000"
colspan="3"></td>
        </tr>
        <tr>
            <td height="10" colspan="3"></td>
        </tr>
    </table>
<?>

```

```

function GetMonthName($month)
{
    $month_name = "";

    switch($month)
    {
        case 1:
            $month_name = "January";
            break;
        case 2:
            $month_name = "February";
            break;
        case 3:
            $month_name = "March";
            break;
        case 4:
            $month_name = "April";
            break;
        case 5:

```

```

        $month_name = "May";
        break;
    case 6:
        $month_name = "June";
        break;
    case 7:
        $month_name = "July";
        break;
    case 8:
        $month_name = "August";
        break;
    case 9:
        $month_name = "September";
        break;
    case 10:
        $month_name = "October";
        break;
    case 11:
        $month_name = "November";
        break;
    case 12:
        $month_name = "December";
        break;
}

return $month_name;
}

function DisplayErrors($errors)
{?>
    <table border="0" cellpadding="0" cellspacing="0">
        <tr>
            <td bgcolor="#c0c0c0"><font face="Tahoma"
size="2"><b>&nbsp;The following errors
occured:</b></font></td>
        </tr>
        <tr>
            <td></td>
        </tr>
        <tr>
            <td><font face="Tahoma"
size="2"><?echo($errors);?></font></td>
        </tr>
        <tr>
            <td></td>

```

```

        </tr>
        <tr>
            <td><font face="Tahoma" size="2"><b><a
href="javascript: history.back();">Back</a></b></font></td>
        </tr>
    </table>
<?>

```

```

/*sub SendEmail(strTo, strFrom, strSubject, strBody)
    set objEmail = server.CreateObject("CDONTS.NewMail")

    objEmail.To = strTo
    objEmail.From = strFrom
    objEmail.Subject = strSubject
    objEmail.Body = strBody
    objEmail.Send

    set objEmail = nothing
end sub*/

```

```

function ViewFigure($strFig)
{?>
    <a href="javascript: void
window.open('viewfig.asp?fig=<?echo($strFig);?>', 'viewfig',
'width=550, height=400, resizable=no,
scrollbars=no');">Fig. <?echo($strFig);?></a>
<?>

```

```

function DatabaseOpen()
{
    $link = mysql_connect("mysql.wpi.edu", "bds13",
"8bCmu3") or die("mysql_connect error");
    mysql_select_db("wpidynamics") or die("mysql_select_db
error");
}

```

```

function DatabaseClose()
{
    mysql_close($link);
}??>

```

stylesheet.css

```

INPUT
{
    font-weight:normal;
    font-size:12px;

```



```
        color:#000000;
        font-family:Arial;
    }

TEXTAREA
{
    font-weight:normal;
    font-size:12px;
    color:#000000;
    font-family:Arial;
}

SELECT
{
    font-weight:normal;
    font-size:12px;
    color:#000000;
    font-family:Arial;
}

FONT
{
    font-weight:normal;
    font-size:17px;
    color:#000000;
    font-family:Times New Roman;
}

A
{
    font-weight:normal;
    font-size:17px;
    color:#ff0000;
    font-family:Times New Roman;
}

.Equation
{
    font-weight:normal;
    font-size:17px;
    color:#000000;
    font-family:Times New Roman;
}
```

Appendix E: Website Database

The following is a database that is accessed by the website source code. It does not show up on the actual website but required for the sites operation.

tblOfficeHours

Field	Type	Null	Key	Default	Extra
OfficeHoursId	int(11)		PRI	NULL	auto_increment
FirstName	varchar(255)	YES		NULL	
LastName	varchar(255)	YES		NULL	
Email	varchar(255)	YES		NULL	
Office	varchar(255)	YES		NULL	
OfficeHours	varchar(255)	YES		NULL	
PhoneNumber	varchar(255)	YES		NULL	

tblResources

Field	Type	Null	Key	Default	Extra
ResourceId	int(11)		PRI	NULL	auto_increment
Title	varchar(255)	YES		NULL	
Description	varchar(255)	YES		NULL	
URL	blob	YES		NULL	
Inactive	int(11)	YES		NULL	
AddDate	date	YES		NULL	
AddUserId	int(11)	YES		NULL	
UpdateDate	date	YES		NULL	
UpdateUserId	int(11)	YES		NULL	