Developing an Interactive Learning Network Using Tablet PCs in Sophomore-Level Engineering Courses

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Table of Contents

List of Tables

List of Figures

Abstract:

The importance of active and interactive learning in science and engineering education has long been recognized, and interactive and collaborative teaching and learning techniques are routinely employed in small laboratory and discussion sessions. Wireless technology, coupled with pen-based computing technology that is suited for analyzing and solving engineering problems, provides an ideal venue for applying these interactive teaching and learning methods to a larger, more traditional lecture setting. This study focuses on how Tablet PCs and wireless technology can be used during classroom instruction to create an Interactive Learning Network (ILN) that allows real-time student assessment and assistance. The ILN is designed to enhance the instructor's ability to solicit active participation from all students during lectures, to conduct immediate and meaningful assessment of student learning, and to provide needed real-time feedback and assistance to maximize student learning. This interactive classroom environment is created using wireless Tablet PCs and a software application, NetSupport School, that allows various levels of interactions between the instructor and the students during lectures, thereby enhancing the instructor's ability to systematically monitor and control individual student progress, assess their understanding through instant surveys, and provide immediate feedback and assistance through the wireless network. Results from two separate controlled studies of the implementation of this model of interactive teaching and learning in sophomore-level Engineering Dynamics courses show statistically a significant positive impact on student performance. Additionally, results of student surveys show overwhelmingly positive student perception of the effects of this classroom environment on their learning experience. These results indicate that the interactive classroom environment developed using wireless Tablet PCs has the potential to be a more effective teaching pedagogy compared to traditional instructor-centered teaching environments, and should be applied to math, science and other engineering courses.

1. INTRODUCTION

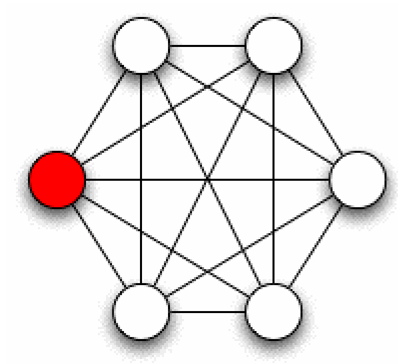
The fundamental problem addressed by this study is the lack of active participation of students during classroom instruction in the traditional lecture setting. Studies have long shown that the traditional instructor-centered lecture format is an ineffective learning environment, and that active participation, as well as interactive and collaborative teaching and learning methods, are more effective in various areas of science and engineering education including Chemistry[1], Physics[2], Engineering[3], and Computer Science[4]. Various uses of technology have been found to be effective in enhancing the classroom experience to achieve more interactive and collaborative environments. These techniques include handheld wireless transmitters in Personal Response Systems (PRS)[5], various forms of computer-mediated collaborative problem solving[6], and the use of wireless Tablet PC technology[7].

Tablet PCs are essentially laptop computers that have the added functionality of simulating paper and pencil by allowing the user to use a stylus and write directly on the computer screen to create electronic documents that can be easily edited using traditional computer applications. This functionality makes Tablet PCs more suitable than laptop computers in solving and analyzing problems that require sketches, diagrams, and mathematical formulas. Combined with wireless networking technology, Tablet PCs have the potential to provide an ideal venue for applying previously proven collaborative teaching and learning techniques commonly used in smaller engineering laboratory and discussion sessions to a larger, more traditional lecture setting. Currently, the range of use of Tablet PCs in the classroom includes enhancing lecture presentations[8], digital ink and note taking[9], E-Books (books in electronic format) that allow hyperlinks and annotations[10], and Tablet-PC-based in-class assessments[7]. As the use of Tablet PCs in the classroom grows, there is a growing need to understand how these various uses and applications can facilitate and enhance student learning.

This paper summarizes the preliminary results of a series of studies on how Tablet PCs and wireless technology can be used during classroom instruction to create a model that is highly interactive. In this paper, this model will be referred to as an Interactive Learning Network (ILN). Figure 1 is a schematic of the ILN model of instruction showing the various two-way interactions between the instructor and the students during lecture sessions. This paper will also address the effects of these technology-enhanced interactions and collaborations on student performance, on student attitude towards the ILN model of instruction and the use of Tablet PCs in the classroom, and on the student level of engagement and confidence in the learning process. It is expected that these studies will show that compared to courses taught with a traditional instructor-centered mode, the Interactive Learning Network can lead to:

- better student performance in the courses where the technology is implemented, as indicated by better student grades on homework, quizzes, and tests compared to courses that do not use the technology,
- positive attitude towards the use of the ILN model of instruction, and towards student use of Tablet PCs in the classroom,
- better student engagement in courses using the technology, as evidenced by higher attendance rates and more time spent on assigned tasks outside class time, and
- higher student perceived confidence in their mastery of the subject.

Figure 1. Schematic of the Interactive Learning Network showing the interactions between the instructor (red) and the students (white).



2. METHODOLOGY

2.1 The Dynamics Class at Cañada College

Cañada College is part of the 108-school California Community College system, and is one of the smallest community colleges in the San Francisco Bay Area with approximately 6,000 students. The college is a federally-designated Hispanic Serving Institution with approximately 42 percent Latino students. Cañada's Engineering Department is a two-year transfer program with approximately fifteen to twenty students transferring to a four-year institution every year. The Dynamics course at Cañada College is a three-unit, sophomore-level lecture course required of all Civil and Mechanical Engineering majors and some Electrical Engineering and Computer Engineering majors depending on the student's transfer institution. The class meets for three hours a week for sixteen weeks, and covers topics in particle and rigid body plane motion kinematics and kinetics (see Appendix A for a copy of the syllabus). In the traditional instructor-centered approach to teaching Dynamics, the instructor presents new concepts, derives important equations related to the concepts, and then presents a collection of illustrative sample problems that are solved by the instructor in detail. Additional examples are assigned as homework problems. Periodic assessment of student learning is done in the form of quizzes and tests given during the duration of the semester. Success in this course using this approach has been limited, as Dynamics has traditionally been an engineering course that has high attrition rates.

2.2 The Interactive Learning Network (ILN)

The Interactive Learning Network (ILN) is designed to enhance the instructor's ability to solicit active participation from all students during lectures, to conduct immediate and meaningful assessment of student learning, and to provide needed real-time feedback and assistance to maximize student learning. This interactive classroom environment is created using wirelessly networked Tablet PCs and a software application, NetSupport School, that allows various levels of interactions between the instructor and the students during lectures. In this model of instruction, less time is spent by the instructor delivering content through traditional instructor-centered lectures. The lectures focus on introducing new concepts and applying them to a few simple examples with more complex examples given as guided exercises. Students can access the instructor's presentation and add their own annotations using Windows Journal or PowerPoint. Throughout the lecture, the NetSupport School software allows the instructor to quickly assess individual student understanding of concepts using instant student surveys. At the end of each lecture, more involved examples are introduced as exercises that students work on individually or in groups on their Tablet PCs using Windows Journal and/or other appropriate software (Excel, Matlab, MultiSIM, PSPICE, AutoCAD, etc.). While students work on more challenging problems, the instructor has the capability to scan and monitor students' work from the instructor's tablet PC, and guide the students and assess their progress through NetSupport's Survey mode using a series of short, previously prepared leading questions. Individual student questions are received through the Help Request feature, and individual assistance can be provided using the Monitor, Share, and Control features. The instructor is also able to effectively manage the various interactions through group chat, use of an electronic whiteboard, file transfer and distribution, as well as control of student computer applications and web activity. The effectiveness of this model comes from the ability of the instructor to monitor and interact with individual students while they analyze problems on the computer using an input device that allows them to write and manipulate formulas, and make sketches and diagrams.

This method of instruction was developed and implemented in a number of sophomore-level engineering courses at Cañada College from Fall 2005 to Fall 2006. Results of the implementation on two Dynamics classes will be the focus of this paper.

2.3 The Two Case Studies

To study the impact of the Interactive Learning Network model of instruction, two case studies were done: Study 1 involved comparing two Cañada College Dynamics courses, the Fall 2005 class that used the ILN model, and the Fall 2004 class that used the traditional instructor-centered model. Study 2 involved comparing two Dynamics courses from two different institutions in the Fall 2006 semester, a class at Cañada College that used the ILN model, and a class at San Francisco State University that used the traditional model.

2.3.1 Study 1: Cañada College Fall 2005 and Fall 2004

The Interactive Learning Network was first implemented in a Dynamics class of seventeen students at Cañada College in Fall 2005. Since Cañada College offers only one section of this class every fall semester, a comparison group could not be established for the study. Instead, the performance of the Fall 2005 experimental group that used the ILN model was compared with that of the Fall 2004 Dynamics class of eighteen students. Similar homework, quizzes, and exams were given to both Dynamics classes. An attitudinal survey was also administered at the end of the Fall 2005 semester to evaluate students' opinion of and satisfaction with the use of the ILN model and Tablet PCs in the classroom.

Table 1 shows a comparison of student demographics for the two Dynamics classes that were compared in this part of the study. The two Dynamics classes were very similar demographically. The Fall 2005 class (ILN model) started with seventeen students, and the Fall 2004 (non-ILN) class started with eighteen students. For both years, more than 80% of the students were male, and a majority of the students were Mechanical Engineering majors. For both years, the ethnic distribution was diverse, with no majority ethnic group.

Table 1. Demographic comparison of Fall 2005 and Fall 2004 Dynamics students.

	Experimental Fall 2005 (ILN)		**Comparison** Fall 2004 (non-ILN)	
Demographics	**N**	**%**	**N**	**%**
Gender				
Female	1	5.9%	3	16.7%
Male	16	94.1%	15	83.3%
Total	17		18	
Ethnicity				
Afro-American	0	0.0%	0	0.0%
Asian	4	23.5%	3	16.7%
Caucasian	6	35.3%	4	22.2%
Filipino	0	0.0%	2	11.1%
Hispanic	5	29.4%	5	27.8%
Other	2	11.8%	4	22.2%
Total	17		18	
Major				
Civil Engr	1	5.9%	5	27.8%
Mechanical Engr	13	76.5%	11	61.1%
Electrical Engr	1	5.9%	1	5.6%
Computer Engr	0	0.0%	1	5.6%
Other	2	11.8%	0	0.0%
Total	17		18	

2.3.2 Study 2: Fall 2006 Dynamics at Cañada College and San Francisco State University

For Fall 2006, two sections of Dynamics courses were studied, one at Cañada College and one at San Francisco State University (SFSU), with both classes taught by the same instructor. As noted above, Cañada College offers only one section of Dynamics every fall semester. To study the impact of the ILN model on student performance in the Dynamics class at Cañada College, the Dynamics class at San Francisco State University was selected to be the comparison group. In both courses, the instructor used a Tablet PC and a combination of PowerPoint and Windows Journal presentations to deliver lectures. The only major difference between the two classes was the student use of Tablet PCs and NetSupport School in the Cañada College class to create the Interactive Learning Network. Students in the Cañada class use Tablet PCs to take notes, to analyze and solve problems using software applications such as Window's Journal, MATLAB and Excel, and to interact with the instructor through NetSupport School software's Instant Survey, Electronic Whiteboard, Chat and Help Request features.

The Dynamics course at SFSU was a three-unit lecture course that met three hours a week for fifteen weeks, one week shorter than Cañada's sixteen-week course. The first fifteen weeks of the Cañada class covered topics that were identical to SFSU's topics. For the last week the Cañada class covered a topic that was not covered at SFSU and not included in any of the tests. The last homework set at Cañada was not included in the analysis and comparison of the performance of the two groups.

Table 2 shows a comparison of the demographics of the two groups of students for Study 2. The class sizes for the both classes were smaller than normal with only ten students in Cañada's Dynamics class, and seventeen in SFSU's Dynamics class in the beginning of the semester. A comparison of the demographics of the two groups of students showed that the Cañada College class was more diverse in ethnicity and majors than the SFSU class, where students were 76% Civil Engineering majors, and 65% Caucasian. With respect to gender, the Cañada group had a slightly higher percentage of female students (30% vs. 23.5%).

Table 2. Demographic comparison of Fall 2006 Dynamics students at Cañada College and San Francisco State University.

	Experimental Cañada 2006 (ILN)		**Comparison** SFSU 2006 (non-ILN)	
Demographics	**N**	**%**	**N**	**%**
Gender				
Female	3	30.0%	4	23.5%
Male	7	70.0%	9	76.5%
Total	10		17	
Ethnicity				
Afro-American	0	0.0%	0	0.0%
Asian	4	40.0%	3	17.6%
Caucasian	2	20.0%	11	64.7%
Filipino	1	10.0%	1	5.9%
Hispanic	3	30.0%	1	5.9%
Other	0	0.0%	4	5.9%
Total	10		17	
Major				
Civil Engr	2	20.0%	13	76.5%
Mechanical Engr	4	40.0%	4	23.5%
Electrical Engr	2	20.0%	0	0.0%
Computer Engr	0	0.0%	0	0.0%
Other	2	20.0%	0	0.0%
Total	10		17	

To better compare the two groups of students in Study 2, an online first week survey was given to both groups in the beginning of the semester. The first week survey determined, among other things, the number of units students were taking for the semester, the expected number of hours of work, the number of hours a week students were planning to devote to studying for the class, the percentage of time students planned to study in a group, and the expected grade for the class (see Appendix B for a complete list of questions.)

Table 3 shows a summary of the responses of the students to the online first week survey. As can be seen, Cañada College students were taking on the average 3.1 less units, were expecting to work about 5.2 hours more every week, were expecting to study slightly more for the Dynamics class, had about the same expected average grade for the class, and a slightly higher but statistically insignificant grade in the prerequisite Physics course when compared with the students from SFSU.

Table 3. Comparison of responses to the online first week survey.

Question	**Experimental** Cañada (ILN) N=10	**Comparison** SFSU (non-ILN) N=17
How many units (including this class) are you taking this semester?	11.1	14.2
Approximately how many hours a week are you planning to work this semester?	19.0	13.8
How many hours a week (outside class time) do you expect to study for this class?	6.5	5.9
What grade do you expect in this class? (Scale: A=4.0, B = 3.0, C=2.0, D=1.0, F=0.0)	3.6	3.5
What was your grade in the first semester Physics class, or its equivalent? (Scale: A=4.0, B = 3.0, C=2.0, D=1.0, F=0.0)	3.0	2.7

Note: The figures shown in the table represent the average of the responses given by the students in each class.

Due to the inherent differences between the two groups of students in Study 2 (Cañada College being a community college, and SFSU being a university), a diagnostic test was given to the both groups to ascertain whether the students' levels of preparation for the class were comparable. The diagnostic test (see Appendix C) consisted of ten multiple-choice questions measuring student knowledge of basic Mechanics concepts and their applications. These questions involved topics that were covered in the prerequisite Physics course. Results of this diagnostic test showed no statistically significant difference in the average and median scores of the two student groups.

2.4 PROCEDURES

2.4.1 Classroom Formats

Table 4 summarizes the similarities and differences in the classroom structure of the experimental and comparison groups of the two case studies. For the two experimental groups that used the ILN model, students used Tablet PCs during lectures, and interactivity during delivery of new topics was achieved using NetSupport's Instant Survey and electronic whiteboard features that allow participation from all students. As previously described, most of the illustrative examples were given as exercises that students solved using the Tablet PCs while the instructor observed and guided their progress, and provided individual assistance through the NetSupport School software. For the comparison, non-ILN groups, the class structure was instructor-centered and non-interactive both during the introduction of new topics and solutions of illustrative examples.

The last row of Table 4 shows that for three of the four groups (2005 Cañada, 2006 Cañada, and 2006 SFSU) the instructor used the same method in generating and delivering lecture notes to the students. For these three groups, the instructor used a Tablet PC in combination with PowerPoint and Windows Journal to deliver class material. The Tablet PC replaced the blackboard and chalk (or whiteboard and pen), making it possible to have an electronic record of all the lecture notes prepared before and during class. An outline of the day's lecture was usually prepared using a combination of PowerPoint and Windows Journal presentations. During lectures, the instructor added and saved handwritten annotations, sketches, derivations, illustrative problems, and problem solutions to the lecture notes that were then posted on the class website. This allowed subject material to be covered more efficiently and adjustment of the class agenda to be done more easily to accommodate student progress. For the non-ILN Fall 2004 Cañada group, the traditional chalk and blackboard was the main medium for generating and delivering lecture notes.

Table 4. Comparison of classroom formats for the experimental and comparison groups of Study 1 and Study 2.

	Study 1		**Study 2**	
Classroom Format	**Experimental** Cañada 2005 (ILN)	**Comparison** Cañada 2004 (non-ILN)	**Experimental** Cañada 2006 (ILN)	**Comparison** SFSU 2006 (non-ILN)
Student Use of Tablet PC	Yes	No	Yes	No
Lecture Delivery of New Material	Interactive with Students using NetSupport	Not Interactive	Interactive with Students using NetSupport	Not Interactive
Presentation of Illustrative Sample Problems	Interactive with Students using NetSupport	Instructor only	Interactive with Students using NetSupport	Instructor only
Instructor Lecture Notes	Tablet PC	Blackboard and Chalk	Tablet PC	Tablet PC

2.4.2 Data Analysis

To measure the impact of the Interactive Learning Network on learning, the performance of the ILN and non-ILN groups for each of the two case studies were compared. For each case study, scores of the two groups of students on fifteen homework sets, five quizzes, four tests, and a final examination were compared. Identical homework problems were assigned from the textbook for the ILN and non-ILN groups within the same case study (Study 1 or Study 2). Appendices D, E and F give sample problems from the quizzes, tests, and final examination. The average scores for the experimental and comparison groups were computed and independent Student *t*-tests were used to evaluate the statistical significance of the results.

To determine students' attitudes towards the use of Tablet PCs and the Interactive Learning Network model of class instruction, an attitudinal survey was given to the two experimental groups at the end of the semester. This survey (see Appendix G) has two parts: one on NetSupport School use and one on student use of Tablet PCs. It was designed to determine students' perceptions of the impact of the ILN model on student learning and teaching effectiveness. Simple averages of student responses were computed to summarize the results.

For the two student groups of Study 2, additional surveys were designed and administered. An end-of-semester survey was designed to determine students' attitudes towards the course, study habits during the semester, expected grade in the course, and confidence in their performance in and knowledge of the class (see Appendix H.) Simple averages of student responses were computed and compared between the experimental and comparison groups.

While not part of the formal research study, a survey on note-taking strategies (see Appendix I) was developed and administered to understand the effects of the instructor's use of a Tablet PC to deliver course content on students' note-taking habits. This survey also attempted to determine student use of and attitude towards instructor lecture notes generated using a Tablet PC. This survey was also given to at the end of the semester to both groups of Study 2, and the average student responses were computed and summarized for both groups.

3. RESULTS

3.1 Study 1: Cañada College Fall 2005 and Fall 2004

In this section, performance of the two groups of students, Fall 2005 class with ILN format and the Fall 2004 class with a traditional format, will be compared. Additionally, results of the attitudinal survey on student perception of and satisfaction with the ILN model of instruction and the use of Tablet PCs will be presented.

3.1.1 Class Performance Comparison

A summary of the comparison of the performances of the two groups of Dynamics students is shown in Table 5. Quiz Average is the average of five quizzes, Homework Average is the average of fifteen homework sets, and Test Average is the average of four tests. The last column of Table 5 is the difference between the average scores received by Fall 2005 students and Fall 2004 students. There is a significant difference between 2004 and 2005 results in each of the categories, with the biggest differences for homework and quizzes. The difference between the 2004 and 2005 results is statistically significant for homework [$t(1,19) = 3.084$, $p < .01$], for quizzes [$t(1,27) = 3.425$, $p < .005$], for tests [$t(1,22) = 2.393$, $p < .05$] and for the final exam [$t(1,20) = 2.308$, $p < .05$].

Table 5. Comparison of Dynamics student performance for fall 2005 and fall 2004.

Categories	**Experimental** Fall 2005 (ILN) N=15	**Comparison** Fall 2004 (non-ILN) N=15	**Difference***
Quiz Average	84.0	71.4	12.6
Homework Average	92.8	83.0	9.8
Test Average	86.1	77.0	9.1
Final Exam	84.9	70.9	14.0

*Note: For each category, the difference in the results for the ILN and the non-ILN groups is statistically significant [$p < .05$].

3.1.2 Attitudinal Survey on Tablet PC and NetSupport School: Fall 2005 only

Table 6 summarizes the results of the attitudinal survey administered in the Fall 2005 ILN class at the end of the semester. They show overwhelmingly positive attitudes towards the use of both NetSupport School software and Tablet PCs in the classroom. With respect to the use of NetSupport School, the “Help Request” feature was perceived most positively by students, with the control features (locking of student computers, Internet, and Applications controls) viewed the least positively. With respect to the use of Tablet PCs in the classroom, students viewed them as helpful in improving student performance and the instructor’s teaching efficiency, and creating a better learning environment.

Table 6. Summary of student opinions of NetSupport School and Tablet PC use in the classroom.

Use of NetSupport School Software Response Scale: 4 – Strongly Agree, 3 – Agree, 2 – Disagree, 1 – Strongly Disagree, 0 – No Opinion.	**Average Response** (N=15)
NetSupport School program was helpful in improving my performance.	3.30
NetSupport improved the instructor's teaching effectiveness.	3.42
NetSupport enhanced the teacher's ability to measure student learning.	3.45
The "Help Request" feature of NetSupport was useful to me.	3.75
The "Lock," "Internet Control," and "Applications Control" features helped me pay attention to the lecture.	3.17
My overall experience with NetSupport School has been positive.	3.45
Use of Tablet PCs Response Scale: 4 – Strongly Agree, 3 – Agree, 2 – Disagree, 1 – Strongly Disagree, 0 – No Opinion.	**Average Response** (N=15)
Using the Tablet PCs in class helped me improve my performance.	3.36
Tablet PC use improved the instructor's teaching effectiveness.	3.42
Tablet PCs available for use during class created a better learning environment than without them.	3.62
I found "Windows Journal" and the stylus intuitive and easy to use.	3.77
I would like to have Tablet PCs available for student use in other courses.	3.85
My overall experience with Tablet PCs has been positive.	3.77

3.2. Study 2: Fall 2006 Dynamics at Cañada College and San Francisco State University

The performance of the two groups of Dynamics students, the ILN Cañada class and the SFSU class that use the standard instructor-centered approach will be compared in this section. Additionally, results of the survey on student engagement, expectations and confidence on mastery of course content will be presented.

3.2.1 Class Performance Comparison

Table 7 shows a comparison of the performance of the two groups of Fall 2006 Dynamics students. Quiz Average is the average of five quizzes, Homework Average is the average of the fourteen homework sets, and Test Average is the average of four tests. The last column of Table 7 is the difference between the average scores received by Cañada students and SFSU students. It is significant to note that none of the Cañada students withdrew from the class while four (or 24% of the original seventeen) of the SFSU students withdrew. The tabulated results also show higher scores for the Cañada (ILN) class in all categories. Again, as with the results of Study 1 above (Cañada's Fall 2005 ILN class versus Fall 2004 non-ILN class), differences between the scores are statistically significant for Quiz Average [$t(1,20) = 5.108$, $p < .001$)] and Homework Average [$t(1,14) = 2.178$, $p < .05$]. The differences for the Test Average and Final Exam are not statistically significant. However, the corresponding letter grade for the Test Average was a "B" for the Cañada College class, and a "C" for the SFSU class. Furthermore, the difference of 6.7 points on the Test Average most likely would have been statistically significant if the class sizes were larger.

Table 7. Comparison of Fall 2006 dynamics student performance for the Cañada College class and the SFSU class.

Categories	**Experimental** Cañada (ILN) N=10	**Comparison** SFSU (non-ILN) N=13	**Difference** (Cañada – SFSU)
Quiz Average	91.2	67.0	24.2*
Homework Average	90.6	76.5	14.1*
Test Average	83.4	76.7	6.7
Final Exam	84.1	81.5	2.6

*Note: The difference is statistically significant [$p < .05$].

3.2.2 End-of-Semester Survey: Student Engagement, Expectations and Confidence

For this research, student level of engagement in the course was indicated by their attendance and time spent studying for the course outside class time. Since the instructor did not take roll during the semester for either class, the end-of-semester survey asked students to estimate their total number of hours of absence. Table 8 shows that the average student-estimated number of hours of absence was much higher for the SFSU class. The table also indicates that the end-of-semester student-estimated number of hours of study outside class time was higher for Cañada than SFSU. For Cañada students, the average of 7.2 hours a week of study represented an increase compared to the first-week survey estimate of 6.5 hours. For SFSU, the average of 5.2 hours a week was lower than the first-week survey estimate of 5.9 hours. These survey results, showing better attendance and more study hours, are indications that the Cañada group was more engaged in the course than the SFSU group.

Table 8. Summary of survey results on student engagement.

Categories	**Experimental** Cañada (ILN) N=10	**Comparison** SFSU (non-ILN) N=17
Student-estimated number of hours of absence	2.3	8.5
End-of-semester student-estimated number of hours a week of study outside class time	7.2	5.2
First-week survey estimated number of hours of week outside class time students are planning to study	6.5	5.9
Frequency of studying with at least one other student Never = 0, Seldom = 1, Sometimes = 2, Often = 3, Always = 4	1.5	1.5

Table 9 shows a comparison of the averages of student expected grades at the beginning of the semester based on the first-week survey, the end-of-semester survey, and the actual grade obtained in the class. Although student expectations in the beginning of the semester were very similar, the expectations in the non-ILN SFSU class decreased dramatically at the end of the semester, both compared to their initial expectations and when compared to the ILN Cañada class. For both groups, the expected grade at the end of the semester was slightly higher than the actual class grade.

Table 9. Comparison of student expected grades in the beginning of the semester, expected grades at the end of the semester, and actual grades.

Grades (Scale: A=4.0, F=0.0)	**Experimental** Cañada (ILN) N=10	**Comparison** SFSU (non-ILN) N=13	**Difference** (Cañada – SFSU)
Expected Grade (First Week Survey)	3.6	3.5	0.1
Expected Grade (End of Semester)	3.4	2.9	0.5
Actual Grade	3.3	2.7	0.6

The end-of-semester survey also measured student attitudes towards the Dynamics course and their perceived confidence in their knowledge of the material. When asked how difficult the class was compared to other science and engineering courses students have taken or were taking, Cañada students found the class between “as difficult” and “slightly more difficult” while SFSU students found it to be between “slightly more difficult” and “much more difficult.” When asked to compare the amount of study time spent in the Dynamics class compared to other courses, Cañada students’ average response was between “about the same” and “slightly more” while SFSU students’ average response was between “slightly more” and “much more.” When asked to rate their confidence in having learned the material in class, the Cañada group’s average response was between “very confident” and “confident” while the SFSU group was between “confident” and “neutral.”

Table 10. Summary of the end-of-semester survey results on confidence in and attitude towards the Dynamics course.

Question	**Experimental** Cañada (ILN) N=10	**Comparison** SFSU (non-ILN) N=17
Compared to other Engineering or Science courses you have taken or you are currently taking, how difficult is the material covered in this class? Much easier = 0, Slightly easier = 1, About the same = 2, Slightly more difficult = 3, Much more difficult = 4	2.8	3.3
Compared to other Engineering or Science courses you have taken or you are currently taking, how much time did you spend studying for this class? Much less = 0, Slightly less = 1, About the same = 2, Slightly more = 3, Much more = 4	2.4	3.2
How confident are you about having learned the material covered in this class? I should take the class again = 0, Not confident =1, Neutral = 2, Confident = 3, Very confident = 4	3.2	2.3

3.2.3 Attitudinal Survey on Tablet PCs and NetSupport School: Cañada only

A survey of student opinions on the use of NetSupport School and Tablet PCs in the classroom was administered to the Fall 2006 Cañada class at the end of the semester. The results of the survey are shown in Table 11. As with the ILN class of Fall 2005, the "Help Request" feature was perceived most positively by students. Most students agreed or strongly agreed that both the NetSupport School and Tablet PCs had positively impacted their performance in class, and improved teaching effectiveness.

When asked the open-ended question what they like most about the NetSupport School software and the Tablet PCs, students responses included increased attentiveness and focus during lectures, real-time assessment of their knowledge through polling, immediate feedback on their work, increased one-on-one time with the instructor, ease of communication with instructor, and quick assistance when needed.

Table 11. Summary of student opinions of NetSupport School and Tablet PC use in the classroom.

Use of NetSupport School Software Response Scale: 4 – Strongly Agree, 3 – Agree, 2 – Disagree, 1 – Strongly Disagree, 0 – No Opinion.	**Average Response** (N=10)
NetSupport School program was helpful in improving my performance.	3.78
NetSupport improved the instructor's teaching effectiveness.	3.78
NetSupport enhanced the teacher's ability to measure student learning.	3.67
The "Help Request" feature of NetSupport was useful to me.	4.00
The "Lock," "Internet Control," and "Applications Control" features helped me pay attention to the lecture.	3.75
My overall experience with NetSupport School has been positive.	3.78
Use of Tablet PCs Response Scale: 4 – Strongly Agree, 3 – Agree, 2 – Disagree, 1 – Strongly Disagree, 0 – No Opinion.	**Average Response** (N=10)
Using the Tablet PCs in class helped me improve my performance.	3.56
Tablet PC use improved the instructor's teaching effectiveness.	3.78
Tablet PCs available for use during class created a better learning environment than without them.	3.88
I found "Windows Journal" and the stylus intuitive and easy to use.	3.67
I would like to have Tablet PCs available for student use in other courses.	3.56
My overall experience with tablet PCs has been positive.	3.89

3.2.4 Survey on Note-Taking Strategies and Use of Instructor Notes: Cañada and SFSU

Table 12 shows the results of the survey of student note-taking strategies. Students in both groups indicated changes in their note-taking habits in the class compared to their other classes. Among SFSU students, 54% of students reported not taking any notes during class and

31% taking less notes in their Dynamics class compared to other classes. For Cañada students, 40% did not take any notes and 50% took fewer notes than other classes.

Table 12. Results of Survey on Note-Taking Strategy for 2006 Cañada and 2006 SFSU Dynamics classes

Which of the following best describes the amount of lecture notes you take during class? Encircle only **ONE** choice.	**Cañada** (N=10)	**SFSU** (N=13)
I do not take lecture notes during class.	40%	54%
I take fewer notes in this class compared with my other classes.	50%	31%
I take **the same amount** of notes in this class as in other classes.	10%	7%
I take **more notes** in this class than I do in other classes.	0%	7%
Which of the following best describes your use of instructor's lecture notes posted on the class website? Choose only **ONE**.	Cañada (N=10)	SFSU (N=13)
I **rely completely** on the posted lecture notes.	50%	62%
I **rely mostly on the posted notes**, and supplement them with my own notes	40%	23%
I **rely mostly on my own class notes** but I supplement my notes with those posted on the class website.	10%	15%
I **rely completely** on my own notes and **never** use the notes posted on the class website.	0%	0%

Table 13 shows the results of the survey of student use of lecture notes generated by the instructor using a Tablet PC. Both groups found that the posted lecture notes were useful, that the instructor's use of Tablet PC increased teaching effectiveness, that taking fewer notes during class allowed them to focus more on the lectures, and that they preferred notes created using Tablet PCs over those using blackboard and chalk. Among the advantages of Tablet PC use by the instructor, as noted by students, included less effort on keeping up with lecture notes and more focus on understanding and participating in the lecture, better graphics (color and computer generated), better reliability compared to student-generated notes, and ease of editing by both students and instructor.

Table 13. Results of Survey on Use of Instructor Lecture Notes for 2006 Cañada and 2006 SFSU Dynamics classes

The following questions pertain to the instructor's lecture notes Response Scale: 4 – Strongly Agree, 3 – Agree, 2 – Disagree, 1 – Strongly Disagree, 0 – No Opinion.	**Cañada** (N=10)	**SFSU** (N=13)
1. I find the posted instructor's lecture notes (prepared using Tablet PCs) useful.	4.0	3.7
2. (*Only for students who take fewer notes:*) Taking fewer notes during class has allowed me to focus more on the lectures.	3.5	3.6
3. Having access to posted notes promoted my learning.	3.9	3.5
4. I use the posted notes when doing my homework.	3.5	3.5
5. I use posted notes when studying for an exam.	3.7	3.7
6. I prefer lectures with notes created using Tablet PCs over those using blackboard and chalk.	3.8	3.6

4. SUMMARY AND CONCLUSIONS

In assessing the impact of the Interactive Learning Network on student performance, it is important to determine how the different components of the model positively or negatively affected student learning. One of the most important components of the Interactive Learning Network teaching model is the immediate assessment of student learning and feedback on their performance. Research on learning theory has long shown that immediate feedback is an effective tool in increasing learning efficiency[11]. For the case study at hand, the effect of immediate feedback can be seen in quiz and homework scores of the ILN classes. As a result of solving problems in class with the instructor's guidance, students not only learned the material but gained confidence such that they were more successful in completing homework assignments and were better prepared for quizzes. Consequently, the completion and submission rates of homework assignments for the interactive classes were observed to be much higher compared to the traditional instructor-centered classes. This difference maybe attributed to a tendency observed by the instructor for students in the non-interactive classes to delay studying class material until immediately before a test. For example, during exam review sessions many of the questions raised by students in the non-interactive classes were similar to those raised by students in the interactive classes much earlier in the learning process.

Students in the interactive classes also attributed their improved performance to increased focus and attentiveness during class as a result of instructor's survey questions, and the awareness that the instructor observed their progress. Furthermore, the "Help Request" feature of NetSupport was found useful by the students because it allowed them to ask specific questions anonymously. Another advantage of having students solve problems in class immediately after being introduced to a new concept was that it enabled the instructor to identify common student misconceptions early in the learning process, thereby reducing student frustration when solving problems on their own. This early assessment of student learning sometimes presented a need for the instructor to adjust course material, making the class more dynamic and more responsive to the needs of the students.

The Interactive Learning Network resulted in better student engagement as evidenced by lower attrition, higher attendance rates, and more time spent on assigned tasks outside class time. Students also expressed positive attitudes towards the use of the ILN model of instruction, and towards student and instructor use of Tablet PCs in the classroom.

The use of Tablet PCs in the classroom further resulted in a number of distinct advantages that could have contributed to the improved performance of the ILN students. From the students' point of view, the use of Tablet PCs during lectures provided enhanced note-taking ability, and improved their ability to organize class materials and allowed them to integrate hand-written notes and course materials. These features make a Tablet PC highly adaptable to individual students' learning strategies[4]. From the instructor's point of view, the use of PowerPoint and Windows Journal in presenting material coupled with the ability to incorporate hand-written annotations, sketches, mathematical equations, derivations, and animations increased teaching efficiency by allowing the instructor to cover more material during a shorter period of time. These class notes, along with annotations generated during lectures, can easily be stored in electronic format and made available for student use outside class.

For the two case studies considered in this paper, there was a statistically significant improvement in performance on homework and quizzes for the interactive classes as compared to the traditional classes. The observed gains in the Test Average and Final Exam were statistically significant for the Fall 2005 interactive class, and not statistically significant for the Fall 2006 class, due primarily to higher scores of the Fall 2006 non-ILN SFSU class compared to the Fall 2004 non-ILN Cañada class. Although the average scores on tests and the final exam for the Fall 2006 non-ILN SFSU class were higher than those for the Fall 2004 non-ILN Cañada class, a statistical comparison of the two non-ILN groups could not be justified because the Cañada group was not given a diagnostic test to ascertain whether the groups were comparable. However, the observed better performance of the SFSU class on the tests and the final exam can be attributed to a number of factors including the small class sizes, and the added benefit of the instructor's use of Tablet PC during lectures for the non-ILN SFSU 2006 class.

As revealed by the survey of students' note-taking strategies and habits, the SFSU class perceived an increase in student learning and teaching effectiveness as a result of the instructor's Tablet PC use during lectures. For the non-ILN Cañada 2004 class, the blackboard was the main medium of delivering content during lectures. Furthermore, the instructor believes that the lessons learned in the ILN Cañada 2006 class helped improve teaching effectiveness not only in the ILN class but in the non-ILN class as well. For instance, many of the common misconceptions and problems that students exhibited in the ILN class during interactive problem-solving sessions were discussed and addressed by the instructor in the non-ILN class.

In summary, the studies done here show that the interactive learning environment resulted in improvements in student performance compared to the traditional instructor-centered learning environment. These gains can be attributed to enhanced two-way student-instructor interactions, real-time assessment and feedback on student performance, individualized instruction and early intervention, increased student engagement, and enhanced and more efficient delivery of content.

5. IMPLICATIONS

Classroom

The persistent decline of student enrollment in STEM (Science, Technology, Engineering, Mathematics) majors and the increasing importance of these fields in our nation's global competitiveness warrant the development of pedagogies that develop quantitative and analytical skills. Such skills will maximize students' opportunity for academic success in these highly demanding fields. The results of the limited studies done here indicate that the Interactive Learning Network developed using wirelessly networked Tablet PCs has the potential to be a more effective teaching pedagogy compared to traditional instructor-centered teaching environments.

As technology is infused into the classroom, mathematics, science and engineering faculty in all levels of education should consider using Tablet PCs over laptop and desktop computers in the classroom. Networked Tablet PCs enable students and faculty to analyze problems, collect data, take notes, and combine hand-written and other electronic class materials. They also offer the flexibility to write and manipulate mathematical formulas, draw sketches and add ink annotations when solving and analyzing problems.

Future Research

The sample sizes involved in the studies done were small, and bigger class sizes are needed in further studies to verify that the benefits of individualized instruction, immediate assessment and feedback, early intervention and increased student engagement brought about by the Interactive Learning Network model of instruction can be extended to larger class sizes. Furthermore, studies should be done in a larger institution using multiple sections of the same course to ensure that the experimental and comparison groups are comparable, thus increasing the reliability of the results. These studies should attempt to isolate the impact of the various components of the Interactive Learning Network on student learning to determine whether the immediate feedback through instant polling during lectures, the guided questions during problem solving, the individual monitoring of student progress, the individual assistance and instruction, or some combinations of these factors are responsible for improved student performance.

Additionally, these studies should attempt to delineate the effects of Tablet PC use by the instructor from the effects brought about by enhanced interactivity due to student use of Tablet PCs in the classroom. This can be done by comparing student performance of three groups of students: a group with Tablet PCs used by both the instructor and the students (ILN), a second group wherein only the instructor uses a Tablet PC and only for delivering content (instructor-centered with Tablet PC), and a group wherein the instructor uses chalk and blackboard (instructor-centered without Tablet PC).

Similar studies should be done on courses with high attrition rates, courses that are traditional “bottle necks” for STEM students, and courses that are problem-solving intensive and requiring high levels of critical thinking. Finally, other software applications that promote interactivity in the classroom should be considered in conjunction with Tablet PC use.

6. ACKNOWLEDGEMENTS:

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Appendix A
Engineering Dynamics: Course Syllabus

Instructor: Dr. A. G. Enriquez
Office: 16-107
Phone: 306-3261
Email: enriquez@smccd.edu
Hours: 12-2 MW; 2-4 TTh
www.smccd.net/accounts/enriquez

Course: 88853 Units: 3.0

Description: Kinematics and kinetics of particles; two-dimensional and three-dimensional kinematics and kinetics of rigid bodies; vibrations. Basic Skills Level: 1. Prereq: Physics 250 and Engr 230.

Text: Beer and Johnston, Vector Mechanics for Engineers: Dynamics, 7th Ed, McGraw-Hill, 2004.

COURSE REQUIREMENTS:

Student Readings: Reading assignments from the textbook will be given at the end of each class meeting. It will be beneficial to the student to read the assigned sections before coming to class. Students are encouraged to take note of any questions that may arise while reading the text and ask them during the class.

Homework: Homework problems will be assigned every class meeting. Answers to selected problems are given at the back of the textbook. An average of about **6-7 problems per class meeting** will be assigned but **only a few** of the problems will be graded thoroughly. Additionally, *Computer Problems* to solved using MATLAB will be assigned at the end of each chapter. Work **must** be done on 81/2 × 11 paper and a diagram **must** be drawn for each problem. The end of each class will be devoted to discussing difficult homework problems.

Suggested Homework Format:

Given: A concise statement of the information supplied.
A sketch of the original system should be included where helpful.

Find: A concise statement of the required information.

Solution:

- Make additional sketches necessary (FBD's) labeling dimensions and coordinate systems needed.
- Working from the diagrams, list the basic equations and assumptions to be employed.
- Using the equations, work through the analysis, simplifying the algebra as much as possible before substituting numerical values. (Much insight into the dynamics of the system can be gained from the symbolic representation of the solution.)
- Substitute numerical values as needed in the problem to obtain a numerical result.
- Inspect the answer to make sure it is reasonable. For numerical answers, determine whether the magnitude (and direction) is reasonable. For algebraic answers, check the dimensions of the results.

Grading Policies:

Quizzes (may or may not be announced) will be given at the **beginning** of the class. There will be **absolutely no make-up** quiz given for any reason. Students are expected to attend each class meeting and be prepared for each quiz by doing the assigned problems and readings. There will be four one-hour **Tests** accounting for 60% of the semester grade. **Make-up** tests **will not** be given unless **prior arrangements** have been made. The **Final Examination** (25% of the semester grade) may be **comprehensive**. The final exam schedule is as follows: Tuesday, December 12, 11:10-1:40 p.m.

The final grade (**FG**) will be determined from quizzes and homework (**QH**), tests (**TA**) and a final examination (**FE**) as follows:

$$\mathbf{FG} = 0.15\,\mathbf{QH} + 0.60\,\mathbf{TA} + 0.25\,\mathbf{FE},$$

where: **QH** is the average of the quizzes and homework, **TA** is the average of the tests, and **FE** is the final examination.

The corresponding letter grade is given by the following table:

Grade	FG
A	90-100
B	80-89
C	65-79
D	55-65
F	0-54

A student who gets a grade of 60% or less in any of the tests or quizzes should see the instructor immediately to devise a plan to improve the student's performance in class.

COURSE OUTLINE

Week	Discussion Topic	Sections	Homework Problems
1	Introduction; Rectilinear Motion	11.1-5	11.2,12,16,34,40,44, 11.C3
2	Dependent Motion; Curvilinear Motion	11.6,9-12	11.49,94,100,105,118,121,
3	Tangential/Normal; Radial/Transverse	11.13-14	11.134,139,143,162,170, 11.C4
4	Newton's Second Law of Motion	12.1-6	12.11,19,35,39,46,55
5	Angular Momentum; Curvilinear Motion	12.7-10	12.65,71,77,81,92, 12.C5
6	Work and Energy	13.1-5	13.4,14,19,28,46
7	Potential Energy; Impulse and Momentum	13.6-11	13.56,63,71,127,134, 13.C2
8	Impact	13.12-15	13.156,168,173,187
9	Systems of Particles	14.1-9	14.3,21,33,49
10	Kinematics of Rigid Bodies	15.1-6	15.1,13,23,39,57,64,69, 15.C4
11	Plane Motion	15.7-11	15.75,84,110,124,131,152,175
12	D' Alembert's Principle	16.1-5	16.7,25,29,52,71
13	Kinetics of Plane Motion	16.6-8	16.96,99,105,113,122, 16.C3
14	Work-Energy for Plane Motion	17.1-7	17.1,11,15,30,35, 17.C2
15	Impulse-Momentum for Rigid Bodies	17.8-12	17.46,88,98,105
16	General Motion	15.12-15	15.184,190,202

Appendix B

First Day Survey

1. **Name:**
2. **Major:**
3. **Email Address:**
4. **Phone Number:**
5. **Are you willing to share your phone number with the rest of the class? (Y/N)**
6. **Student Level:**
   Freshman
   Sophomore
   Junior
   Senior
   Graduate Student
   Don't Know
7. **Approximate Number of College Units Completed (include all colleges you have attended:**
   Less than 30
   Between 30 and 70
   Between 70 and 100
   More than 100
   Don't Know
8. **Ethnicity:**
   Asian
   African American
   Filipino
   Hispanic
   Native American
   White
   Other
9. **What is your principal academic goal?**
   BS degree after an AS degree
   BS degree without an AS degree
   Graduate degree
   Others
10. **What was your grade in Phys 250, or its equivalent?**
11. **When did you take the above class?**
12. **What grade do you expect in this (Engr 240) class?**
13. **How many hours a week (outside class time) do you expect to study for this class?**
    $\leq$ 2 hours
    $>$ 2 hours but $\leq$ 6 hours
    $>$ 6 but $\leq$ 10 hours
    $>$ 10 hours

14. Of the hours you are going to study outside class time, how frequent would you spend studying with at least one other student?

Never
Seldom
Sometimes
Often
Always

15. How many units (including this class) are you taking this semester?

16. Approximately how many hours a week are you planning to work this semester?

17. Which of the following campus resources and student services do you regularly use?

Library
Learning Center
Tutorial
Counseling
Career Center
Transfer Center
Financial Aid Office
MESA

Appendix C
Diagnostic Test

Dynamics Diagnostic Test (Do not write your name on the test.)

Questions **1-3** refer to a particle in rectilinear motion along the x-axis.

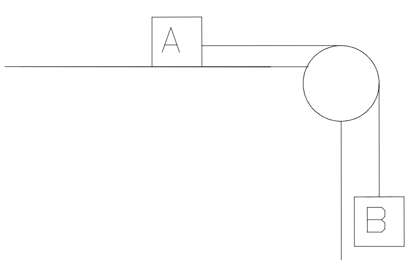
1. If the particle's acceleration is constant, which of the following must be true:
   a. It's velocity is never zero.
   b. It's position changes linearly with time.
   c. It's velocity increases linearly with time.
   d. None of the above.

2. The particle's acceleration is positive when
   a. It is decelerating in positive direction,
   b. It is decelerating in the negative direction
   c. It is moving in the negative direction and its speed is increasing
   d. It is in the positive side of the x-axis, and its speed is increasing.

3. The particles starts from rest at point A and accelerates uniformly towards point C. If point B is halfway between points A and C, what can be said about the particle's speed as it passes B?
   a. Speed at B is one-half the speed at C.
   b. Speed at B is one quarter the speed at C.
   c. Speed at B is about 70% of speed at C.
   d. None of the above.

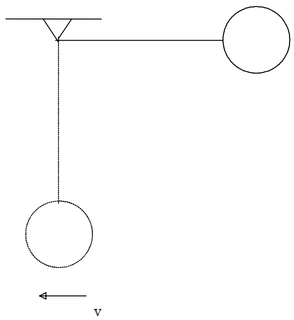
4. A projectile is launched with an initial velocity, v_o, at an angle θ with the horizontal. If the projectile's initial velocity is doubled without the changing its angle of launch, which is true regarding the projectile's new range:
   a. the range does not change
   b. the range at twice the initial velocity is twice the original range
   c. the range at twice the initial velocity is four times the original range
   d. the range increases by a factor of square-root of 2.

5. Two particles in uniform circular motion such that A of mass m_A moves at speed v_A along a circle of radius R_A while B of mass m_B moves at a speed v_B along a circle of radius R_B. If $m_A = 2\ m_B$, $v_A = 2v_B$, and $R_A = 2\ R_B$, which is true regarding the particles' accelerations:
   a. $a_A = a_B$ b. $a_A = 2a_B$ c. $a_A = 4a_B$ d. $a_A = 8\ a_B$



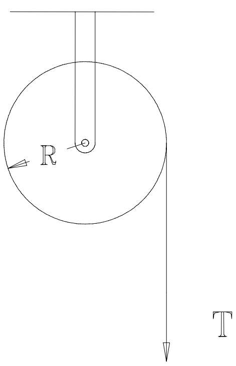
7. Blocks A and B, both of mass m, are released from rest at the position shown. Neglecting friction between A and the horizontal surface, the tension in the cable right after the blocks are released is
   a. mg
   b. less than mg
   c. greater than mg
   d. zero.

7. A sphere of mass m is attached to an inextensible string of length L and of negligible mass. The system is released from rest when the string was horizontal. The speed, v, of the sphere when it reaches the lowest position is



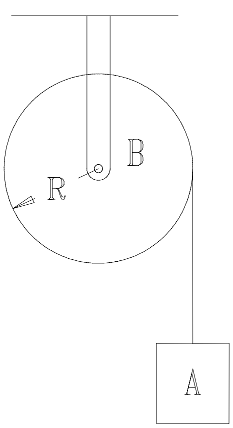
a. $2gL$
b. gL
c. $\sqrt{2gL}$
d. $\sqrt{gL}$

8. Two identical billiard balls collide on a smooth horizontal table. Which of the following best describes the impact?
a. Total momentum and kinetic energy are conserved.
b. Total momentum and kinetic energy are not necessarily conserved.
c. Momentum is conserved but kinetic energy is conserved only if collision is perfectly elastic.
d. Momentum is conserved but kinetic energy is conserved only if collision is perfectly plastic.



9. A uniform disk of mass m and radius R rotates freely about a smooth pin as shown. If the moment of inertia of the disk about its center of rotation is I , its angular acceleration when a tension T is applied as shown is

a. $\alpha = TR/(mI)$
b. $\alpha = T/m$
c. $\alpha = TR/m$
d. $\alpha = TR/I$



Disk B of mass m and radius R rotates freely about a smooth pin. It is connected by an inextensible, massless cable to block A also of mass m . If the system is released from rest at the position shown, the angular velocity of disk B after block A has moved down a distance R is

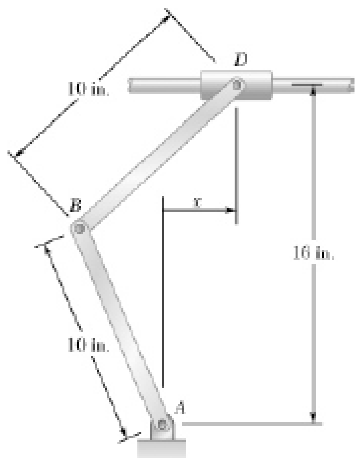
a. $\omega = \sqrt{\dfrac{3g}{4R}}$ b. $\omega = \sqrt{\dfrac{4g}{3R}}$
c. $\omega = \sqrt{\dfrac{3g}{2R}}$ d. $\omega = \sqrt{\dfrac{2g}{3R}}$

Note: The moment of inertia of the disk is $I = \frac{1}{2} mR^2$.

Appendix D
Sample Quiz Problem

Engr 240 – Quiz 3

Name: ___________________________



Collar D slides on a fixed horizontal rod with a constant velocity of 24 in/s to the right. Knowing that at the instant shown, $x = 0$, determine

a) the angular velocities of bars AB and BD,
b) the angular accelerations of bars AB and BD.

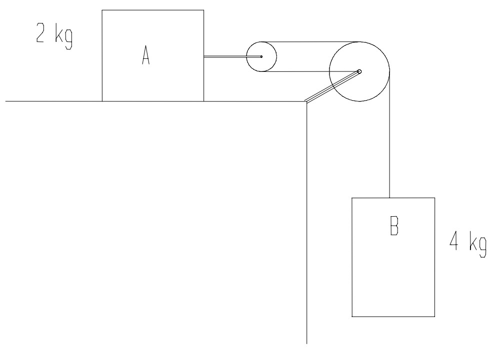
Appendix E
Sample Test Problems

Engr 240 - Dynamics

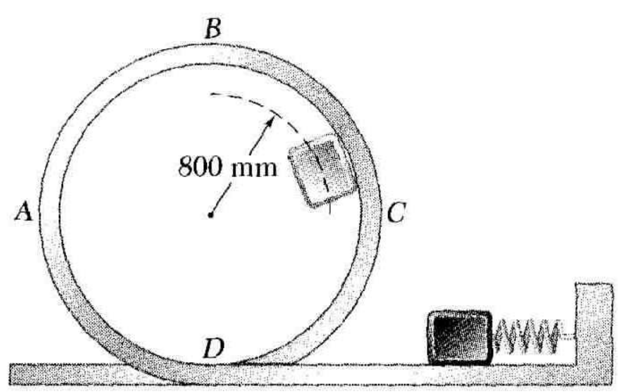
NAME: ________________________

Instructions: Solve each problem completely.

1. Block A of mass 2 kg rests on a rough table and is connected by an inextensible cable to block B of mass 4 kg, as shown. The coefficient of kinetic friction between block A and the table is μ_k=0.1. Neglecting the masses of the smooth pulleys, find the acceleration of block A.

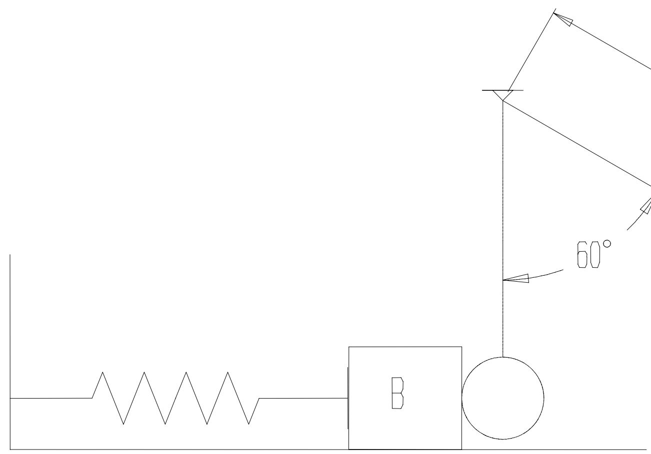


2. A 300-g block is released from rest after a spring of constant k = 600 N/m has been compressed.
    a. Determine the minimum initial compression of the spring for the block to go around a loop without leaving the vertical track ABCD.
    b. Find the force exerted by the track on the block at position A.



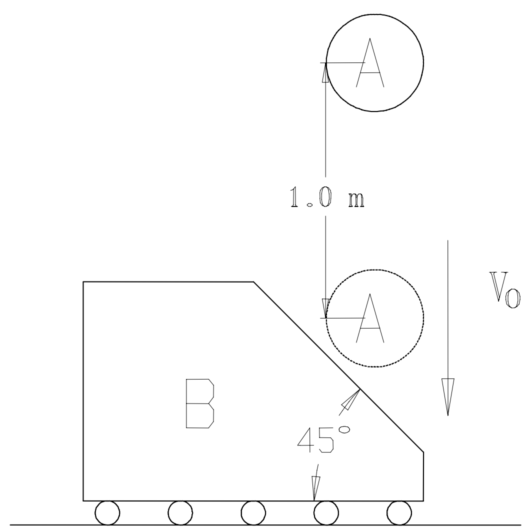
8. The 4-kg sphere A is attached to a 2-m inextensible cable. It is released from rest at the position shown, swings along a vertical plane, and strikes the 8-kg block B. Block B is initially at rest and is attached to a spring of constant k that is initially undeformed. If the coefficient of kinetic friction between B and the horizontal floor is μ_k=0.2, and the coefficient of restitution between A and B is e=0.8, determine

a) the velocity of block B after the impact.
b) the constant k of the spring if the maximum deformation of the spring is 0.3 m.



4. A 1-kg sphere A is released from rest at the given position, drops for a distance of 1.0 m before hitting the 1-kg wedge B.

a. Find the velocity of A before it hits B.
b. If the coefficient of restitution between the sphere and the wedge is e=0.8, determine the velocity of the wedge after impact.



Appendix F
Sample Final Exam

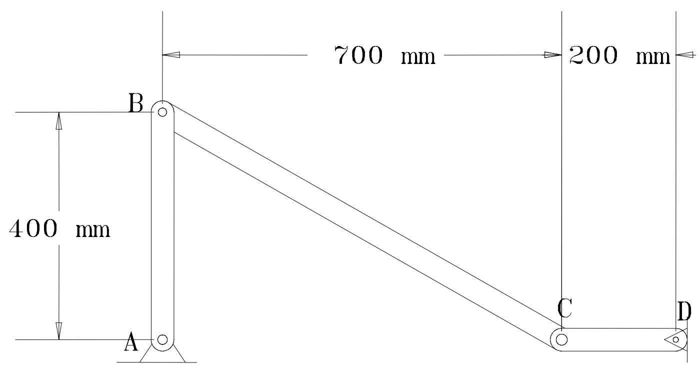
Engr 240 - Dynamics
Final Exam

NAME: ______________________

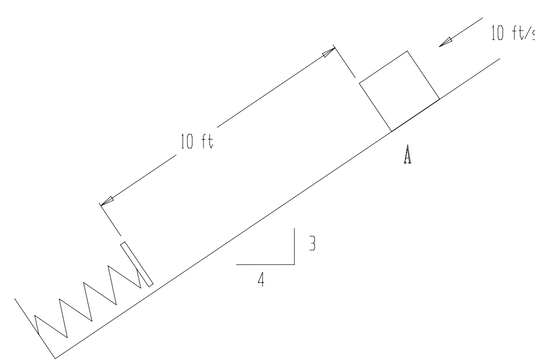
Instructions: Solve all the problems completely.

1. Two automobiles A and B traveling in the same direction in adjacent lanes are stopped at a traffic signal. As the signal turns green, automobile A accelerates at a constant rate of 2 m/s^2. Two seconds later, automobile B starts and accelerates at a constant rate of 3.6 m/s^2. Determine (a) when and where B will overtake A, (b) the speed of each vehicle at that time.

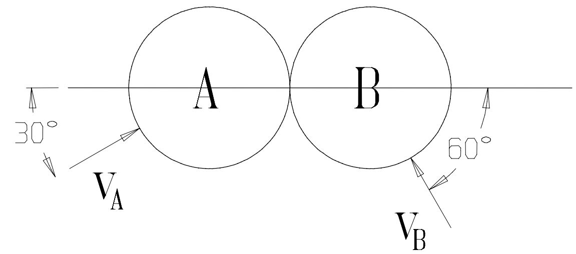
2. At the instant shown, bar AB has a counterclockwise angular velocity of 2 rad/s, and zero angular acceleration. Determine:
a) the angular velocities of bars BC and CD.
b) the angular accelerations of bars BC and CD.



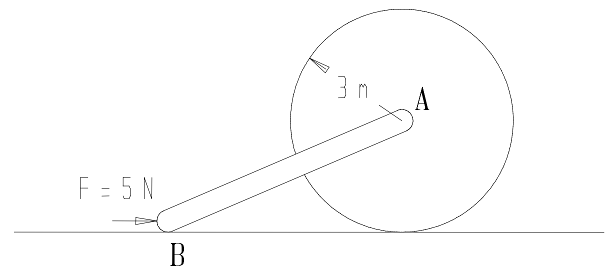
3. The 100-lb block slides down the inclined plane (μ_k=0.25). The spring is of constant k=200lb/ft. If v_A=10 ft/s, determine the maximum deformation of the spring.



4. Two identical spheres A and B each of mass m =2 kg collide while moving with velocities v_A = 5 m/s, and v_B = 5 m/s as shown. If the coefficient of restitution is e = 1, find the velocities of A and B after the collision.



5. Bar AB of mass 2 kg and length 6 m is attached by a smooth pin to disk A of mass 2 kg and radius 3 m. End B of the rod is constrained to move along the horizontal floor. A constant horizontal force F = 5 N is applied at B as shown. If disk A rolls without sliding, and neglecting the friction between B and the floor, determine the angular acceleration of the disk. **(Note:** Bar AB is in translation.)



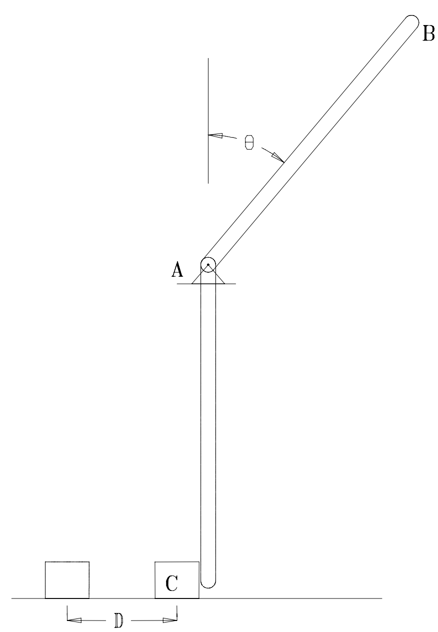
Note: Centroidal Moment of inertia:

$$I_{\text{disk}} = \tfrac{1}{2} mR^2$$

6. The 2-m, 2-kg slender bar AB is supported by a smooth pin at A. The bar is released from rest when θ=40°, swings on a vertical plane and hits the 4-kg block C resting on a rough horizontal floor.

a) Determine the angular velocity of the bar before impact,
b) If the coefficient of restitution of the impact is e = 1.0, find the angular velocity of the bar and the velocity of block C after impact.
c) Find the distance D through which block C slides before coming to a stop. (The coefficient of friction between the block and the floor is μ_k=0.2).

$$I_{\text{rod}} = \tfrac{1}{12} mL^2$$



Appendix G
Attitudinal Survey on NetSupport School and Tablet PC

Please respond to all questions – be assured that your responses will remain confidential. This survey will be used for research and program review purposes only.

On a scale of 1 – 4 (4 = strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree) Please answer the following:

NetSupport School:

The following questions are regarding the use of NetSupport School Software in the class.	Strongly Agree	Agree	Disagree	Strongly Disagree	No Opinion
1. The NetSupport School program was helpful in improving my performance.	4	3	2	1	0
2. NetSupport improved the instructor's teaching effectiveness.	4	3	2	1	0
3. NetSupport (through "Instant Survey" and by "Scanning" student computers) enhanced the teacher's ability to measure student learning.	4	3	2	1	0
4. The "Help Request" feature of NetSupport was useful to me.	4	3	2	1	0
5. The "Lock," "Internet Control," and "Applications Control" features helped me pay attention to the lecture.	4	3	2	1	0
6. My overall experience with NetSupport School has been positive.	4	3	2	1	0

What I like best about NetSupport School is ____.

What I like least about NetSupport School is ____.

On a scale of 1 – 4 (4 = strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree) Please answer the following:

Tablet PC:

The following questions pertain to the use of Tablet PCs during class.	Strongly Agree	Agree	Disagree	Strongly Disagree	No Opinion
1. Using the tablet PCs in class helped me improve my performance in class.	4	3	2	1	0
2. Tablet PC use improved the instructor's teaching effectiveness.	4	3	2	1	0
3. Tablet PCs available for use during class created a better learning environment than without them.	4	3	2	1	0
4. I found "Windows Journal" and the stylus intuitive and easy to use.	4	3	2	1	0
5. I would like to have Tablet PCs available for student use in other courses.	4	3	2	1	0
6. My overall experience with tablet PCs has been positive.	4	3	2	1	0

What I like best about Tablet PCs is ____.

What I like least about Tablet PCs is ____.

Appendix H
End-of-Semester Survey

The following questions pertain to this class (Dynamics) only. Circle your choice.

1. **What grade do you expect in this class?** A B C D F

2. **Estimate the number of hours you were absent during the whole semester (our class met 3 hours a week for 15 weeks).**

Zero	1-3	4-6	7-10	11-12	13-15
16-18	19-21	21-24	25-27	28-30	greater than 30

3. **On the average, how many hours a week (outside class time) did you study for this class? (Select one only.)**
   $\leq$ 2 hours
   > 2 hours but $\leq$ 6 hours
   > 6 but $\leq$ 10 hours
   > 10 hours

4. **Of the hours you studied outside class time, how frequently did you spend studying with at least one other student?**
   Never
   Seldom
   Sometimes
   Often
   Always

5. **Compared to other Engineering or Science courses you have taken or you are currently taking, how much time did you spend studying for this class?**
   a. I studied much less in this class than in other classes.
   b. I studied slightly less in this class than in other classes.
   c. I studied about the about same amount in this class as in other classes.
   d. I studied slightly more in this class than in other classes.
   e. I studied much more in this class than in other classes.

6. **Compared to other Engineering or Science courses you have taken or you are currently taking, how difficult is the material covered in this class?**
   a. Much more difficult than other classes
   b. Slightly more difficult than other classes
   c. About the same level of difficulty as other classes
   d. Slightly easier than other classes
   e. Much easier than other classes

7. **How confident are you about having learned the material covered in this class?**

   Very Confident
   Confident
   Neutral
   Not Confident
   I feel that I should take the class again.

What I like best about this class is ____.

What I like least about this class is ____.

Appendix I
Survey on Note Taking

Which of the following best describes the amount of lecture notes you take during class? Encircle only **ONE** choice.

1. **I do not take lecture notes** during class.
2. **I take fewer notes** in this class compared with my other classes.
3. I take **the same amount** of notes in this class as in other classes.
4. I take **more notes** in this class than I do in other classes.

Which of the following best describes your use of instructor's lecture notes posted on the class website? Encircle only **ONE** choice.

1. I **rely completely** on the posted lecture notes.
2. I **rely mostly on the posted notes**, and supplement them with my own notes
3. I **rely mostly on my own class notes** but I supplement my notes with those posted on the class website.
4. I **rely completely** on my own notes and **never** use the notes posted on the class website.

On a scale of 1 – 4 (4 = strongly agree, 3 = agree, 2 = disagree, 1 = strongly disagree) Please answer the following:

The following questions are regarding the use of posted instructor's class notes.	Strongly Agree	Agree	Disagree	Strongly Disagree	No Opinion
1. I find the posted instructor's lecture notes (prepared using tablet PCs) useful.	4	3	2	1	0
2. (*Only for students who take fewer notes*☺ Taking fewer notes during class has allowed me to focus more on the lectures.	4	3	2	1	0
3. Having access to posted notes promoted my learning.	4	3	2	1	0
4. I use the posted notes when doing my homework.	4	3	2	1	0
5. I use posted notes when studying for an exam.	4	3	2	1	0
6. I prefer lectures with notes created using tablet PCs over those using blackboard and chalk.	4	3	2	1	0
7. I would like to have a copy of the outline of the notes available **during** lectures.	4	3	2	1	0

What I like most about the posted notes is ____.

What I like least about the posted notes is ____