

AC 2010-628: EXPLORING A VALID AND RELIABLE ASSESSMENT OF ENGINEERING AND TECHNOLOGY EDUCATION LEARNING IN THE CLASSROOM

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Title: Exploring a Valid and Reliable Assessment of Engineering and Technology Education Learning in the Classroom.

Abstract

It is common knowledge that No Child Left Behind (NCLB) created a system of accountability that established a baseline for determining school success. To assess student performance, NCBL uses the results of standardized assessments in traditional disciplines.

Since engineering and technology education is not one of the traditional disciplines, only 12 states have engineering and technology education as a requirement .In International Technology Education Association (ITEA) report on the status of technology education in the U.S in 2004, it is clear that there is an interest to include engineering and technology education as part of the overall learning experience.

Some of the possible reasons why engineering and technology education are not one of the core subjects are: the limited established academic structures, lack of qualified teachers, clear assessments policies and instruments and administrative conflicts. In order for engineering and technology education to be accepted as a core subject among others, it will be necessary to address the mentioned issues. Critics complain regarding the lack of valid and reliable assessment methodologies, therefore it is necessary for the educational community, to explore and develop valid and reliable assessment tools specific for engineering and technology education.

When teaching engineering and technology, the expectation is that students will demonstrate their acquired knowledge through the design of projects that will serve as an alternative assessment. To encourage the creativity of the students, it is desirable to use self-directed projects, where students decide and select the project they will design, which will be then graded through a rubric. The structure and assessment protocol for the self-directed project will be introduced and discussed in conjunction with samples of different projects produced by students at the college level in the “Science and Technology in the Arts” course at a urban art and media communication liberal arts and science college. This structure includes 1) a procedure to guide students in the generation of the “Definition of the project”, 2) the generation of a valid and reliable rubric to assess the project and 3) instructions for the evaluators on how to use the assessment tool.

The analysis of the data collected by the writer during the past two years shows a strong correlation between the students’, quizzes and final examination, with the grade of their self-selected project.

In conclusion, it is possible to develop and implement a model that will allow engineering and technology education instructors to assess the content, skills and values learned by their students when each student is working in a self-selected project. This model will make possible for the instructor to objectively assess what the students know with a strong level of validity and reliability.

Literature review

The written test has long been used as a major tool for learning assessment in the past, and is still today, the most prevailing assessment method in education. In written tests, students either select responses from a given pool of possible responses (multiple choice tests) or respond to an item within a certain structure ¹ (short answer or essay tests). Although varieties exist within different types of written tests, they are generally easy to construct and use, which makes them valid and

reliable tools to measure and evaluate student learning, fitting the demands of accountability from all levels of administration: local, state and federal ².

Emerging technology has brought dramatic changes to the society since the 90s. The information age demands new skills from learners, such as technological fluency, communication, collaboration, leadership, problem solving and creativity ³, which cannot be easily measured by written tests. Thus more and more educators have been promoting alternative assessments that not only test students' knowledge and limited set of skills, but also how they apply their knowledge and skills to solve problems and carry out tasks.

As presented by Herman, Aschbacher, and Winters ⁴ different alternative assessment strategies include the use of a common set of conducts and provide a frame where the observer can identify and assess these conducts. Common characteristics of an alternative assessment include:

- Ask students to perform, create, produce, or do something;
- Connect higher level thinking and problem-solving skills;
- Use tasks that represent meaningful instructional activities;
- Invoke real-world applications;
- People, not machines, do the scoring, using human judgment; and
- Require new instructional and assessment roles for teachers.

In general, an alternative assessment will include a component where students will communicate in one way or another, the content of their work to others. Performance assessment is by nature a process that requires extended engagement by students in order to demonstrate their proficiency in the selected subject. For these performances students will invest time and effort to prepare experiments, write reports and scripts to communicate in a proficient way the content of their learning, and produce a final artifact that will accomplish the goal of the assignments that is, to effectively communicate to the observer what they really learned. Although the exact nature of these tasks may differ in terms of (1) subject matter, (2) time for performance, (3) flexibility or choice of topics, and (4) the amount of external support for the student, they share the common characteristic of requiring the students to plan, organize and execute complex tasks⁵.

In the same line of thought, a set of different kinds of learning and assessment strategies have been developed. These strategies are based in the incorporation of authentic tasks; the connection between theoretical learning in the classroom and the application of the acquired knowledge in the work environment; in the assessments.

These strategies include: project-based learning, the case method, problem-based learning, cognitive apprenticeship, situated learning, constructive learning environments, collaborative problem solving, goal-based scenarios, and model elicit activities between others ^{6,7}.

From these strategies many forms of alternative assessment were developed and introduced in the educational circles. One of the most common alternative assessments used in both K-12 ⁸ and higher education ⁹ is the student portfolio, a collection of student works related to a given content area. The process of portfolio making allows continuous evaluation of student strengths and weaknesses. Another form of alternative assessment is performance task, where students are

required to perform tasks or solve problems. Inquiry-based learning can provide opportunities for such assessment ¹⁰.

A common characteristic of the majority of performance tasks, as an authentic assessment, is that they will require that students organize information, consider alternative perspectives, work with significant concepts, and develop different media to communicate, connect to the world beyond the classroom and display knowledge to an audience other than the teacher ¹¹. Students need to master the required content knowledge and necessary learning skills to successfully complete the performance task. For the assessment to be a useful tool to assess students' progress in the learning process, the content knowledge and learning skills assessed through the performance task need to be aligned with the national and state standards.

In synthesis, the alternative assessment comprehensive scope includes many characteristics required to be acquired and developed by students, characteristics that the conventional high stake test has not the capability to significantly assess.

However, the reliability and validity of alternative assessments remain to be major concerns. As an example, research in Australia ¹², revealed the top reason math teachers in Sydney, Australia do not use alternative assessments. The reason was that they regarded the assessment as "too subjective". Another study analyzed 392 samples of alternate assessment portfolios of disabled students and found that quite a number of portfolios failed to measure the academic standards they were supposed to measure ¹³. Elliot and Roach ¹⁴ expressed their concern about the alternative assessments used in many states in the United States saying that "the alternate assessments currently in use in a number of states are technically flawed because of poor alignment with content standards, unreliable scores and scores of unknown validity"

- It is clear from the literature in alternative assessment that the concepts of portfolio assessment or performance assessment are well defined ¹⁵ but there is nowhere in the same document a definition of rating scale or score guide for these assessments. Many states are using some designed checklists as means to score alternative assessments. In their work, Elliot and Roach proposed a definition of rating scales in the way that "Rating scales of achievement are rating scales anchored by descriptive rubrics for quantifying teacher judgments of students' knowledge and skills based on repeated direct and indirect observations". It is possible to see from the presented definition that the need to assess students' artifacts requires a direct intervention of the instructor in the generation of the rubric as well as in the interpretation of student knowledge according to the rubric. This point agrees with the last two characteristics of alternative assessments from the work of Herman ^{5,16} "People, not machines, do the scoring, using human judgment; and Require new instructional and assessment roles for teachers".

Alternate assessments require a large intervention of the instructor to generate its definition and its rating scale, data collection, and interpretation of the rubric to produce a final score linked to the work of the student, when a conventional test is generated for other professionals that are not involved in the daily activities of the instructor classroom. This fact, introduces some points of concern that need to be taken into consideration when defining the alternative assessments to

allow these assessments to have validity and reliability. Ensuring the validity and reliability of the assessment will allow the use of these tools to assess the learning experience of different students, therefore these tools can be used to obtain objective information of students' learning and compare it with other students that used conventional written tests to assess their learning experience.

Beside the major point that is to establish the validity and reliability of the assessment, there are others worth mentioning given the nature of the assessment.

These other points of concern are ^{14,17,18}:

- 1) The generally accepted valid and reliable written test has its established credibility, based on the sound process where there are multiple raters, highly structured rating systems and rater training, content validation by subject matter experts, and a strong and close structure on how to implement the test. In the case of an alternative assessment, although designed by multiple raters, the implementation structure is open to the reality of the classroom, as well as the rate of the product is based in the observation and evaluation of the local instructor.
- 2) The implementation of a "high stakes test" is managed by a third party, without any particular interest in a neutral area and time. The alternative assessment is managed by the local teacher, untimed and embedded in the student's classroom.
- 3) In high stake tests, the local instructor has no participation in the creation implementation and evaluation of the test and is unaware of its content. In the case of alternative assessment, given its nature, although the assessment was closely defined by external sources, the local instructor is aware of the content and is working along the student during the production of the artifacts. These final artifacts are also assessed by the local instructor. In other words: the local instructor has previous knowledge about the assessment, and at the same time it is very difficult for the local instructor to separate his/her participation in the generation of the artifact, at the time the same instructor will assess the work of the students.

It is clear that the administrative side of the educational establishment looks for a valid and reliable assessment that is relatively uncomplicated and trouble-free to design, implement and evaluate. As a product of these demands, students are tested using conventional written high-stakes tests. These high stake tests lead instructors, to implement learning strategies to prepare students to pass the test, changing their learning experience from learning a specific subject to learning specific topics and skills involved in the subject to pass the test. On the other hand, it is the task of education to open different paths for students to explore and enhance their knowledge and discover through their exploration their passion and motivate them to pursue it. Alternative assessments facilitate this self-discovery as well as, with certain "administrative limitations", give indications of the level of the successfulness of the students in their learning process.

The present work will address the possibility of generating a valid and reliable alternative assessment: the self-directed final project. The author will describe a self-directed assessment procedure, in which students will generate a self-directed assessment, from the early design to the final product, including a rubric to use to quantify their work. Then this research will investigate the reliability of the presented approach as an indicator of the students' content knowledge of the material taught in the course. The reliability of this indicator will be tested

using parallel forms, comparing the results of the analysis of the products of the students' self-directed final project assessment with other conventional assessments from the students such as quizzes and a final term examination.

Research question

As presented in the literature review, the use of alternative assessment is limited because it is difficult to design and implement an instrument that will ensure that the results of the assessment will reflect in an objective way what the students know about the assessed topic. It is common knowledge that written exams prepared following the protocols are valid and reliable. In this research, a procedure to produce a self-directed final project assessment will be tested and the grade of the projects produced following the procedure will be compared with the products of other conventional assessment tools used previously in this course. These tools have been designed following the scope and sequence of the course and tested by external reviewers to verify their validity, but there is not evidence collected regarding their reliability.

The research question that this work is addressing is the following:

Is the students' product of the self-directed assessment procedure presented in this work a reliable indicator of the knowledge gained by students during the learning process that took place during the semester in the class Science and Technology in the Arts?

The working hypothesis is that there will be a strong correlation between the score obtained by students through the use of conventional instruments and the score obtained through the implementation of the self-directed final project procedure; therefore the score of the self-directed final project will be a reliable indicator of the students' knowledge in the topics learned during the course.

Methodology

Columbia College Chicago is an art and media communication schools that does not offer a major in science or engineering. The class "Science and Technology in the Arts" is taught at Columbia College Chicago as part of the Liberal Arts and Science curriculum offer by the college to provide the required general education credits. This course is not a requirement for any of the majors offered at the institution. Checking the rosters from the past six years of students that took this course, it is possible to see that there is not a pattern that links students' majors with taking the course. Students' majors vary between the 26 majors offered by the school from Film and Video through Journalism and Fiction Writing and their frequency correlates with the number of students of the given major. For the contrary, there is a pattern when checking in which year the students are in their degree. Most of the students taking the class are freshman or sophomore. This same pattern could be find in the other science classes or in the general education requirements courses the college offers; therefore it is possible to say that the enrollment roster in the class is a random sample of the student population. The requirements for course completion include: laboratory reports, quizzes, a final examination (conventional assessment tools) and a self-directed project (performance assessment). This research will compare the results of the analysis of the products of the students' self-directed final project

assessment with other conventional assessments from the students such as quizzes and a final term examination.

Self-directed final project procedure

In an intent to guarantee that the self-directed final project assessments will have validity, (the assessment reflects the topics that need to be assessed); and reliability; (the grade given to the assessment does not depend on the observers); the self-directed final project procedure was implemented during the course.

Given the nature of the self-directed assessment, the students will develop, based upon their own selection of a topic, a process that will include the acquisition of new content knowledge related to the selected topic, new scientific and technological techniques applicable and necessary to advance their project, and visualization tools and skills that will facilitate the communication of the rest of the class. The final projects are self-explanatory and are presented on the last day of class in a symposium form.

To ensure that the project will fulfill the requirement of the course, students will produce a document, called *Definition of the self-directed final Project*. The document is submitted for formal approval by the instructor, and may be revised by the instructor to ensure alignment with the requirements of the class. After the instructor's approval is obtained, the *Definition of the self-directed Project* document will serve as a "contract" between the student and the instructor concerning the students' responsibilities in the production of the final product. The instructions, step by step, to generate the definition of the project are included in a document titled "guide to the definition of the self-directed final project". This document was provided to the students at the beginning of the semester and discussed with students during the first half of the semester.

Definition of the final project: It is a collaborative intervention between the instructor and the student in which the student will 1) select a topic based in the content of at least six hours of class as presented in the syllabus of the course, 2) define extensively the breadth and depth of the concepts and sub-concepts that the project will include, having clear that these concepts and sub-concepts need to be presented at or above the level of the class and 3) produce a conceptual map of the project to ensure that the project will have a logical flow of ideas and instead of being a collection of facts.

After the review and the approval of the definition of the project it is clear for students and instructor what the contents of the project are. This clarification facilitate the generation of an assessment rubric, that will ensure the content validity at the time of assessing and placing the project's score.

Generation of the rubric: The project will be evaluated primarily on the scientific accuracy and relevance of the contents presented. Students are encouraged to unleash their creativity, for the purpose of effectively communicating scientifically accurate perspectives and knowledge throughout their presentation.

The rubric contains four main areas: 1) **Concepts addressed in the project:** in this case the rubric will ask if the topics, content and sub-contents defined in the project are present in the final product presented, 2) **Depth of the material covered in the project:** the rubric will ask if

each concept was illustrated accurately and completely during the project; (graded as below, at least or above the level presented during the course), and whether a technological application was illustrated in the presentation (this section has three parts: accuracy and completeness of concept addressed; technological application; and at/or/above presentation level of class), 3)

Technology applications of the presented concepts: the rubric will ask if there are evidence in the final project of technological applications of the selected concepts, and 4) **Scientific**

Communication: the rubric will ask about the potential for the project to communicate the scientific information to future students observing the project.

The rubric will be constructed by the students following the concepts and sub-concepts defined previously, ensuring that students are aware of what they need to explore to produce their project and what the evaluator will expect to see in the final product.

Rating procedure: Students enrolled in the course participate in a symposium held on the last day of the schedule classes. In this symposium students present their projects to their classmates and there is a session of questions and answers after the presentation. Given the fact that the projects are self-explanatory, the instructor facilitates the discussion during the presentation time, in which the rating procedure is implemented later. To motivate the participation of students in the discussion, each student has the opportunity to judge the projects of their peers. Peer evaluation is important for student to be able to objectively assess the work of peers, but it is not part of the final grade the project will receive.

After the presentations, the instructor reviews again each project and following the rubric developed for each specific project, assigns the respective value for each concepts and sub-concept, completing the rubric to finally assign a final grade to the self-directed final project.

Data collection during the implementation of the self-directed final project

During the past four semesters Spring 2008, Fall 2008, Spring 2009 and Fall 2009, four groups of students (n=74) participated in the class and produced as part of their class requirements a self-directed project. As mentioned before these students are a random sample of the student body population. Students enrolled in the course needed to produce eight laboratory reports with a weight of 25% of their final grade, three quizzes with a weight of 20% of their final grade, a final take home exam with a weight of 20% of their final grade and a self-directed project with a weight of 35% of their final grade.

The quizzes and final test include all the material developed during the course, as presented in the syllabus of the course. The self-directed final project includes part of the topics developed during the course (but a minimum of six hour content). Some examples of the topics covered for the projects are: The audio system, a movie that describe the fundamentals principles of sound and the technological devices used to produce sound in and artistic performance. Lighting design for a performance, the magnetic tape and its applications and others.

Conventional and self-directed assessment timeline

During the semester, students were evaluated using conventional evaluation instruments (quizzes and final examination) and the self-directed final project. Every four weeks students had 30 minutes in class for open note quizzing regarding the topic learned in the previous weeks. At

week seven, the students were formally asked to follow the self-directed procedure; to produce their final projects and generate the assessment rubrics that the instructor will use to evaluate and grade their projects. The implementation of the final project following the directive lines developed by the student on the *Definition of the self-directed final Project* is produced outside of the time frame of the class with the deadline on the last class of the semester. One week before the end of the semester students received the take home final examination that covers all the material covered during the course. Students have all week to complete the final examination and bring it to the last class, where the symposium showing the self-directed projects of all the students takes place. After the symposium the instructor reviews the self-directed projects using their designed rubrics and grades the projects.

At the end of the semester, and as a result of all the assessments implemented during the course, each student will have a score reflecting their laboratory reports, quizzes, final examination and self-directed final project. These scores and their respective weights will determine the grade of the student.

Data Analysis

During the four semesters a data set was created including 74 subjects and each subject has three scores, two obtained by conventional tools (quizzes and final examinations) and the third, the score of the self-directed final project implemented and evaluated following the described procedure. Using the score of the conventional tools, this research will compare these results with the ones produced by the implementation of the self-directed final project procedure.

To compare between the scores obtained by students through conventional instruments (quizzes and final examination) and the alternative assessment instrument (the self-directed final project procedure) a new variable will be defined, “conventional score”. This variable will have the value of the weight of the quizzes and the final examination in the final score for the student. The variable conventional score also represents the conventional assessment of the content of the course, because the three quizzes and the final examination are covering all the material covered during the course.

Using PASW statistical software (formally SPSS) the correlation between the “conventional score” and the score of the self-directed final project was tested. Two sets of data from the 74 students were boldly outliers, (the students did not perform one of the assessments) and were eliminated. The possible range on the “conventional score” was 0 -100, where higher scores indicated higher knowledge about the topic covered during the course. The possible range on the self-directed final project was 0-100, where higher scores indicated that the project better reflected what was defined in the proposal of the project. There was a significant positive correlation between the “conventional score” and the self-directed final project ($r = .85$, $p = .000$). Therefore the self-directed final project procedure produced a score that is a reliable indicator of the knowledge gained by students during the learning process.

It is possible to see the correlation between these two variables as shown on the figure 1.

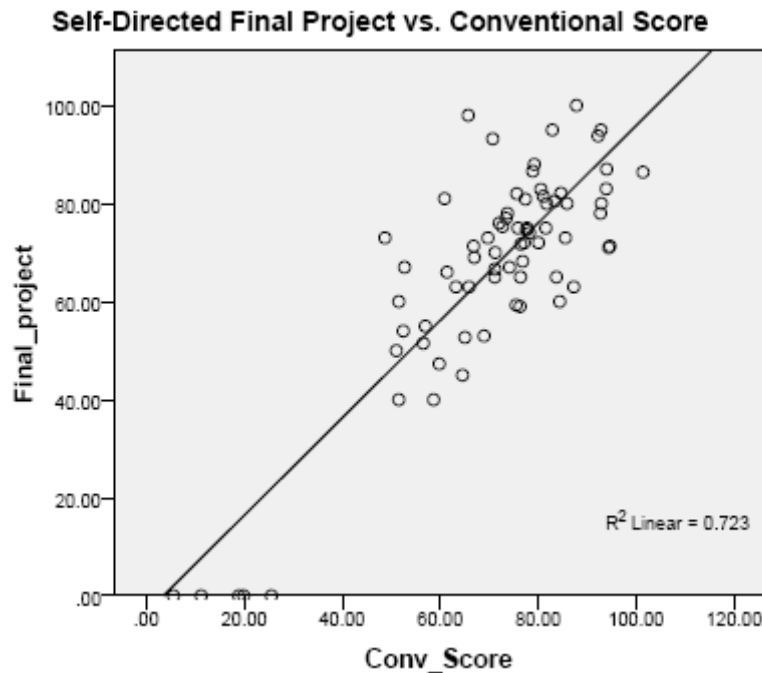


Figure 1. Scatter plot of the Self-Directed Final Project score and the Conventional Score variables .

Also to compare if there is a significant difference between the mean of the conventional and alternative assessment scores, a t-test for independent samples was implemented. The two groups are the “conventional score” and the final project score. These two groups have a normal distribution. There was not a significant difference between the conventional score ($M=70.63$, $SD=19.32$) and final project score ($M=66.77$, $SD=22.58$) conditions; $t(142)=1.01$, $p=0.273$. This result suggests that the score obtained through the alternative assessment is as reliable as the conventional instruments.

Following the results presented above, it is possible to say that, in the presented conditions, 1) there is a strong correlation between the scores obtained through the use of conventional instruments and the scores obtained following the self-directed final project procedure, and 2) there is not a significant difference between the scores obtained through the conventional and alternative assessment, therefore, the results suggest that the score obtained through the implementation of the self-directed final project procedure is a valid and reliable indicator of what the student learn during the course, although the self-directed final project only covers a partial part of the syllabus of the course.

Discussion

The objective of this research was to investigate if the designed self-directed final project procedure will produce a score that is a valid and reliable indicator of what the student learned during the course. The validity of the assessment was defined when the instructor and student decided the contents of the final project and the expectations, by generating a specific rubric for each specific project. The fact that the project content is selected by the students, limit the

possibilities to create a common rubric for all the projects. The point of the reliability of the methodology studied, although the data collected supported that the scores obtained through the self-directed final project are as reliable as the conventional scores, is still based in the knowledge of the rater about the level of the teaching that took place during the semester. The created rubric weighs the assessment of the concepts presented as: below, at least or above the level presented during the course. In this particular research the instructor had the task of the rater. A future extension of this research will include the design of a training procedure to explore the possibility of creating a more general model of self-directed assessment that will ensure also the inter-rater reliability.

Another point of consideration is that the “conventional score” created variable involves all of the contents learned during the course when the final project score only involves the contents defined for the final project. It would be interesting to compare the student’s acquired knowledge in his/her selected contents using a conventional, valid and reliable instrument and a self-directed final project. This will require the development of a parallel conventional test for each self-directed project. Given the experience gained on the presented project it is possible to identify the generic contents selected by the students and prepare a set of questions to create a conventional test that will cover the content selected by the student. The comparison between the specific conventional test and the self-directed project will provide new insights about the reliability of the final project score.

The implementation of the self-directed final project procedure is time consuming for the instructor. In this process the instructor has the possibility to better connect with his/her students, breaking the distance of instructor-student and enhancing the learning community capability to learn and communicate, in this presented case, in topics related to science and technology involved in artistic performances. On the other hand, given the great amount of time and human resources required by this kind of assessment, it is possible to see that the presented model will be difficult to be implemented in a large scale.

Other idea interesting to investigate, based in the results of this projects is using the previous self-directed project definitions generated by the students in past semesters to create a “portfolio of projects”. After reviewing semesters of projects, it is possible to find a clear pattern of topics selected by students. Using these topics to generate well defined projects’ definition, students will select one of the possible projects from the library, and implement it in the media of their choice. Although this process will limit the self-selection of the topics, it will facilitate the implementation of this kind of assessment. This methodology could lead to the development of a model of a standard alternative assessment.

It is time to provide the educational administration with assessment procedures that will provide reliable information about the learning that is taking place in the classroom and at the same time that will enhance the learning experience, making it more relevant to the students. Given the nature of the STEM (Science, Technology, Engineering and Mathematics) fields, the implementation of assessments strategies like the one presented in this research, could enhance the learning experience in the classroom when providing reliable information to the administration regarding the learning in the classroom.

As discussed above, further research is needed particularly to investigate the presented self-directed final project procedure as well as to enlarge the body of knowledge relevant to the

implementation of valid and reliable alternatives assessments, in the educational system in general and not only for a specific population.

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Appendix

- 1) Sample Quiz and Final Examination
- 2) Syllabus of the course
- 3) Guidelines for the generation of the *Definition of the Project* document
- 4) Student sample of a definition of a project and its rubric

Columbia College Chicago

Science and Mathematics Department

Science and Technology in
the Arts

Course # 56-1681

Quiz #2
Spring 2009

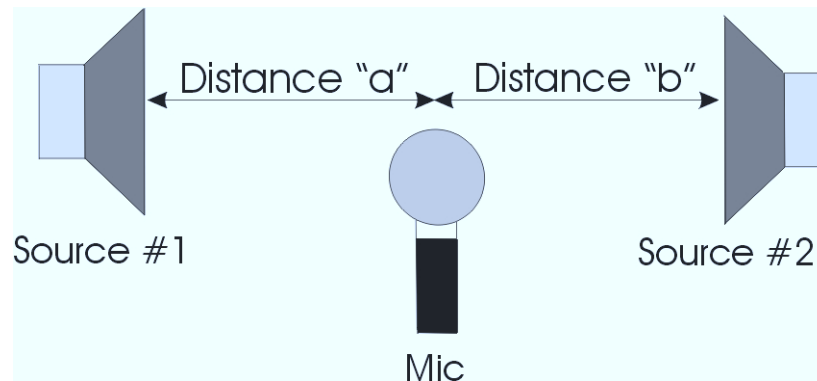
Name	
Date	

Question # 1 (8 points)

There are two sources of sound, Source #1 and Source #2 and one microphone, Mic that capture the sound. There is **not** another source of sound present. Both sources produce a sound, with amplitude of A , a wavelength of λ , and these sources are in phase (meaning, the sources start to produce the sound at the same time)

Assume that the amplitude of the sound remains constant.

Answer the following questions:



1) If the distance “a” (from source #1 to the microphone), is equal to the distance “b” (from source # 2 to the microphone), the amplitude of the sound wave that Mic receives is (circle one answer),

- I) Zero II) A III) 2 times A IV) 3 times A

Explain which kind of interference is taking place in the position of the microphone.

2) If the distance “b” is equal to the distance “a” + $\lambda/2$ the amplitude of the sound wave that Mic receives is (circle one answer),

- I) Zero II) A III) 2 times A IV) 3 times A

Explain which kind of interference is taking place in the position of the microphone.

3) If the distance “b” is equal to the distance “a” + λ the amplitude of the sound wave that the Mic receives is (circle one answer),

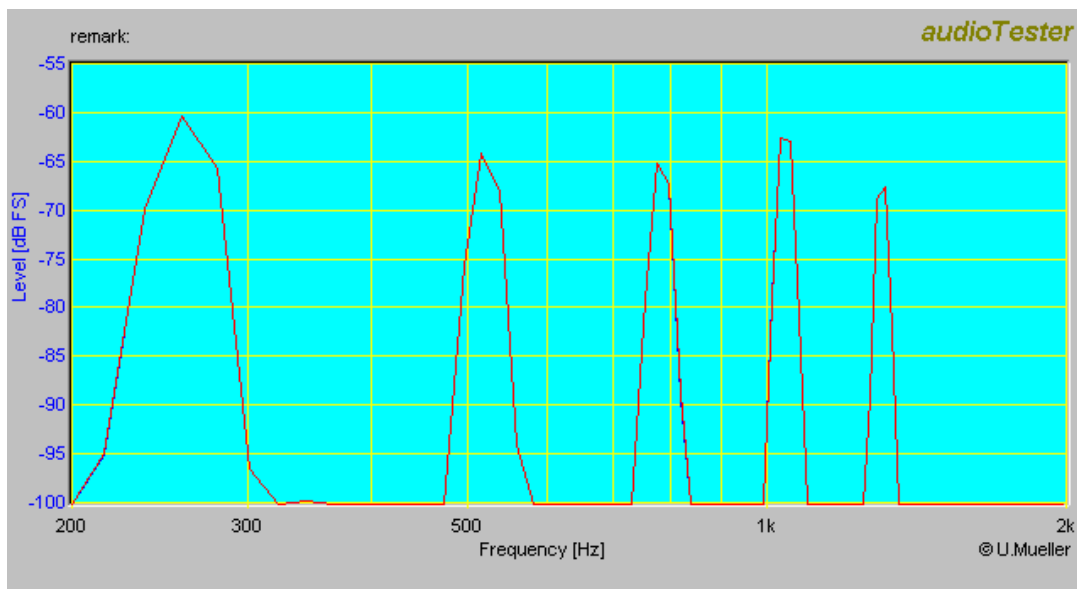
- I) Zero II) A III) 2 times A IV) 3 times A

Explain which kind of interference is taking place in the position of the microphone.

4) Assuming now that the velocity of the sound in the air changes in 20 %. Does this new fact affect your answers to the questions 1), 2) and 3)? Yes / No, justify your answer

Question #2 (26 points)

Given the screen of the spectrum analyzer of a sound source



What are the frequencies and amplitudes produced by the sound source?

Frequencies (Hz)

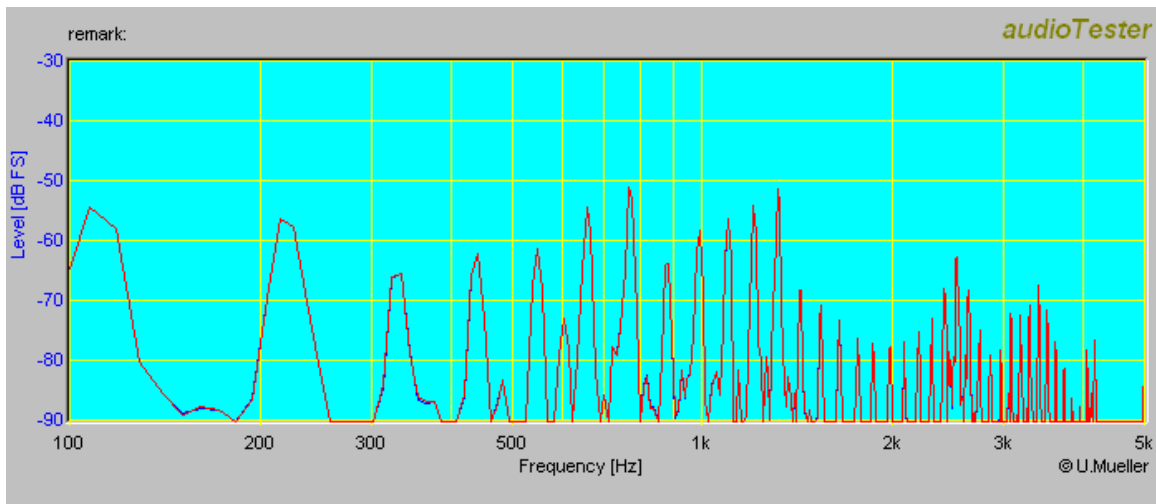
Intensity (dB)

To modify the quality of the sound of the given sound source you are requested to design a system that will cut the frequencies below 600 Hz by 10 dB and boost the frequencies above 600 Hz by 10 dB

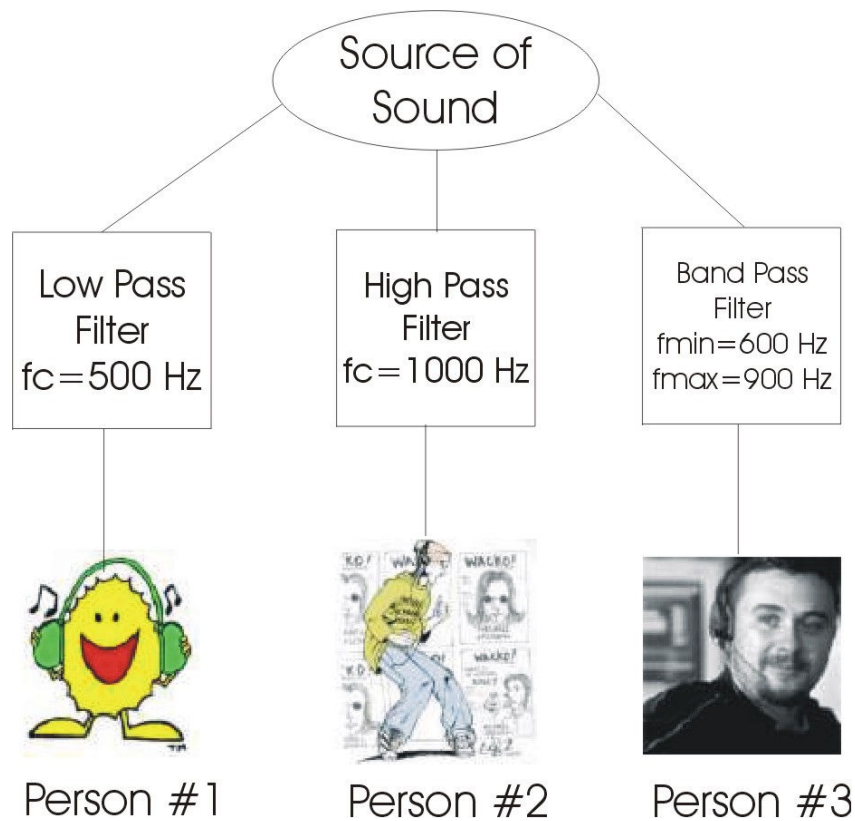
- a) Explain what you need to do to achieve the desired goal. Justify your answer.
- b) Draw a block diagram of the system using simple modules (filters, amplifiers, mixers)
- c) Draw the screen of the spectrum analyzer of the output of the system when the input is the given sound source.

Question #3 (12 points)

An unidentified source of sound is described by its spectrum analyzer screen presented below

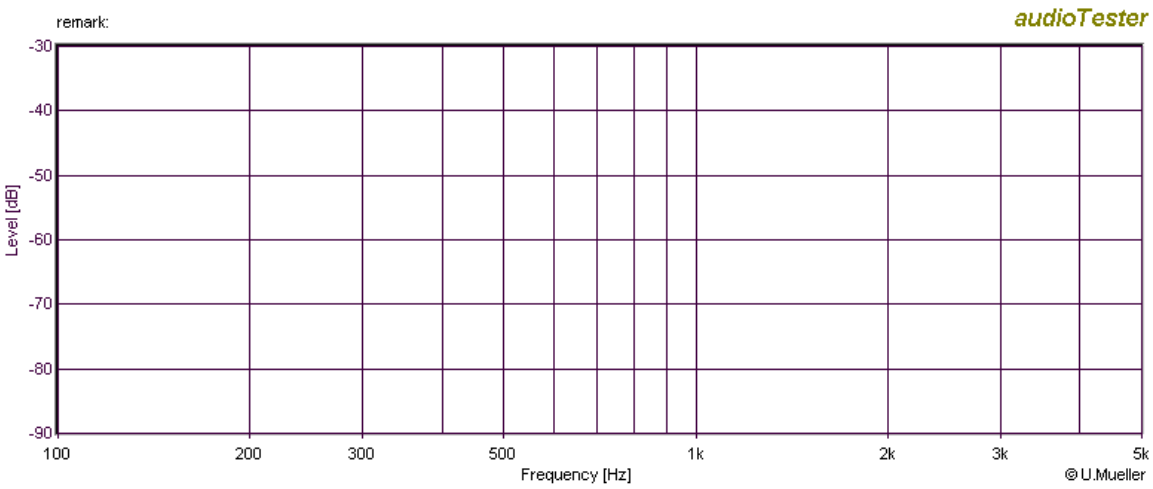


There are three people in the room; each one of them will hear the sound through a set of headphones, after the sound passed through a specific filter as shown in the picture below

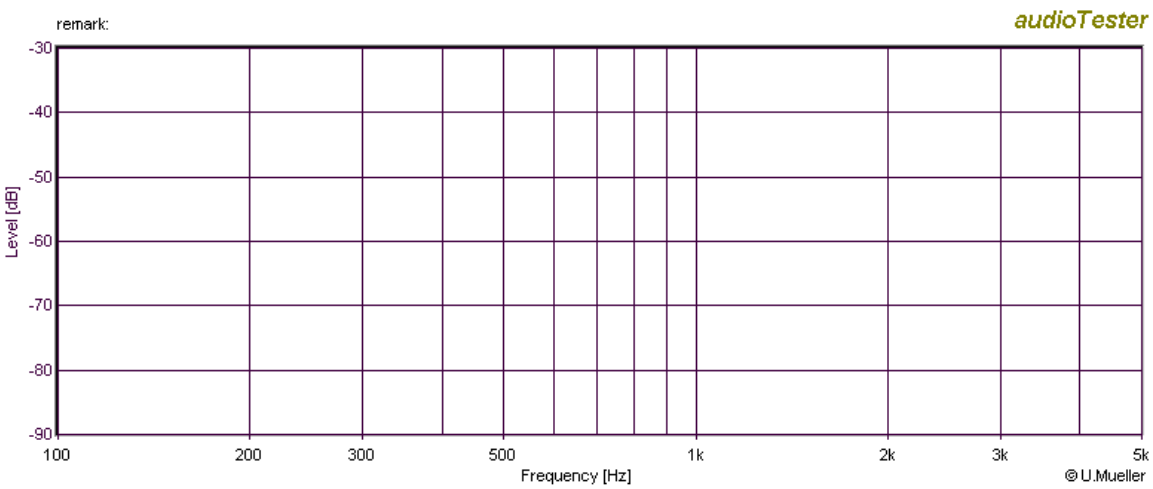


Draw in the spectrum analyzer screen presented below the frequencies each one of the listeners are hearing (frequency and intensity)

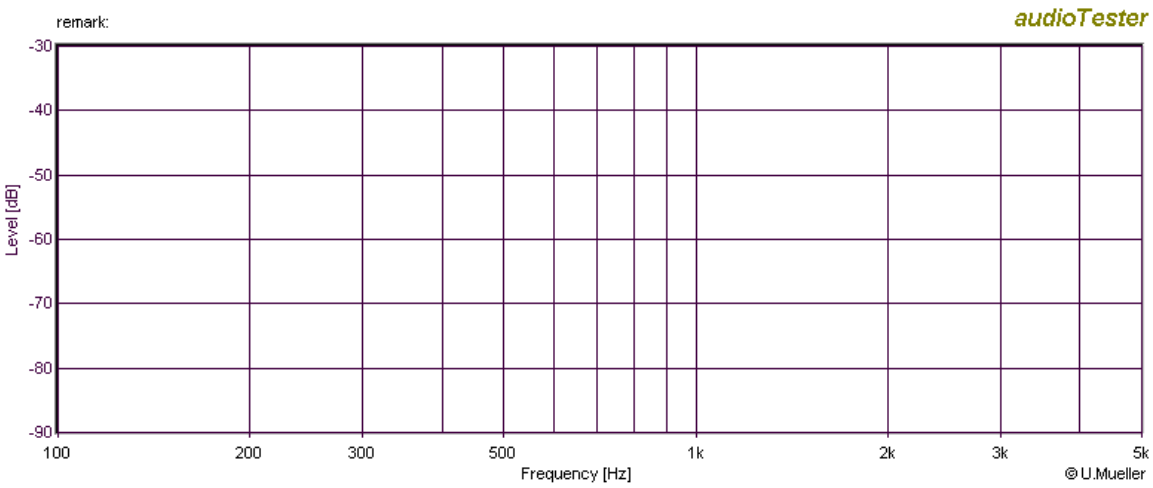
Person #1



Person #2

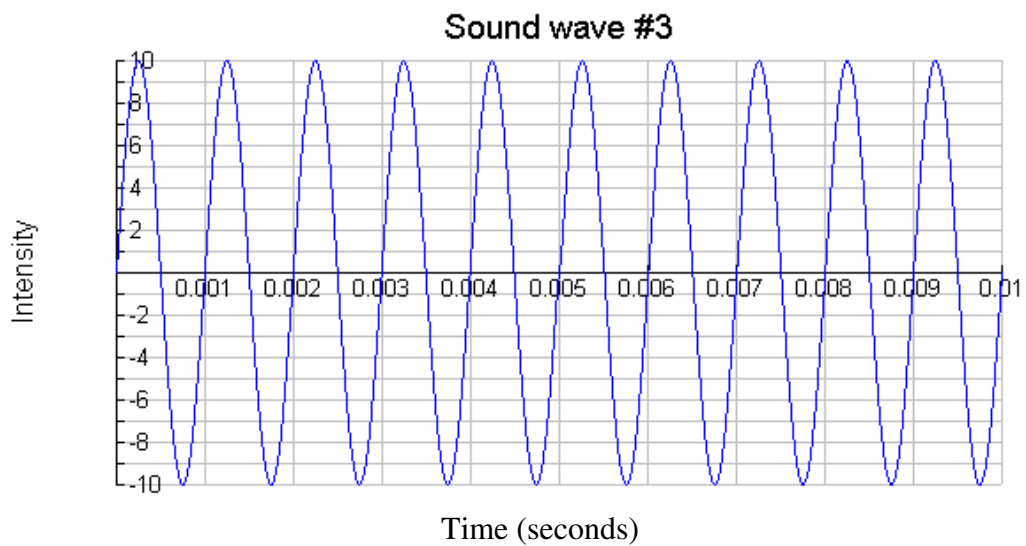
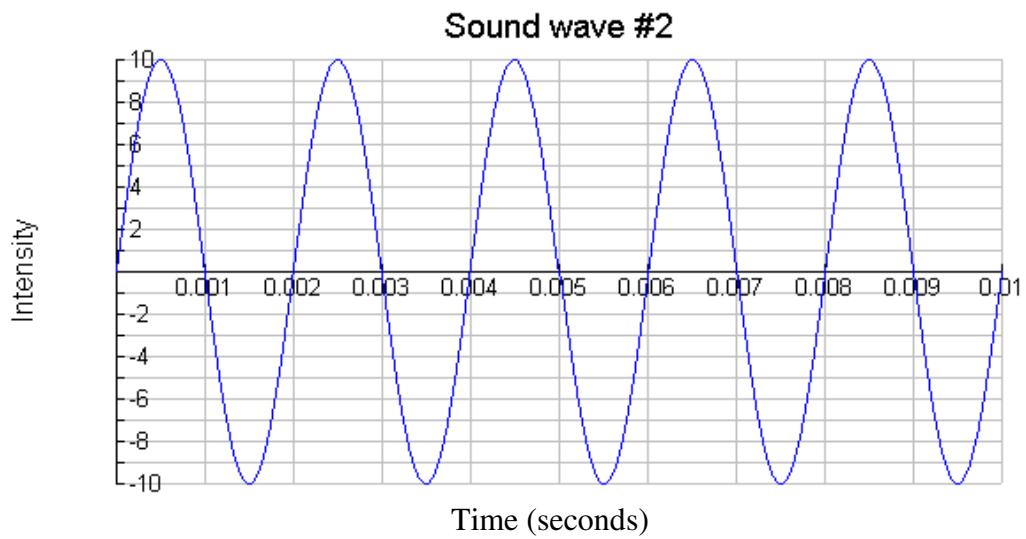
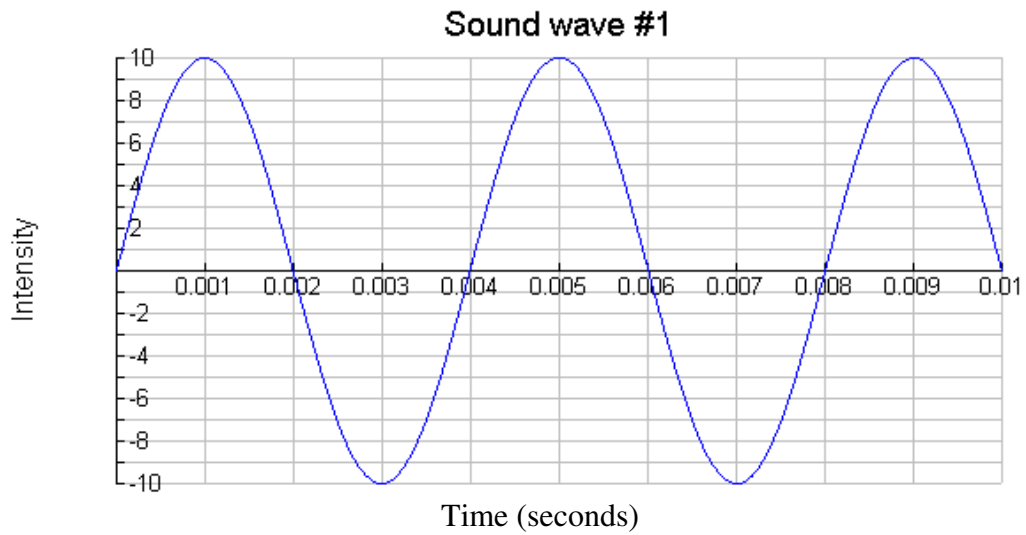


Person #3



Question # 4 (25 points)

Given the following three sound waves



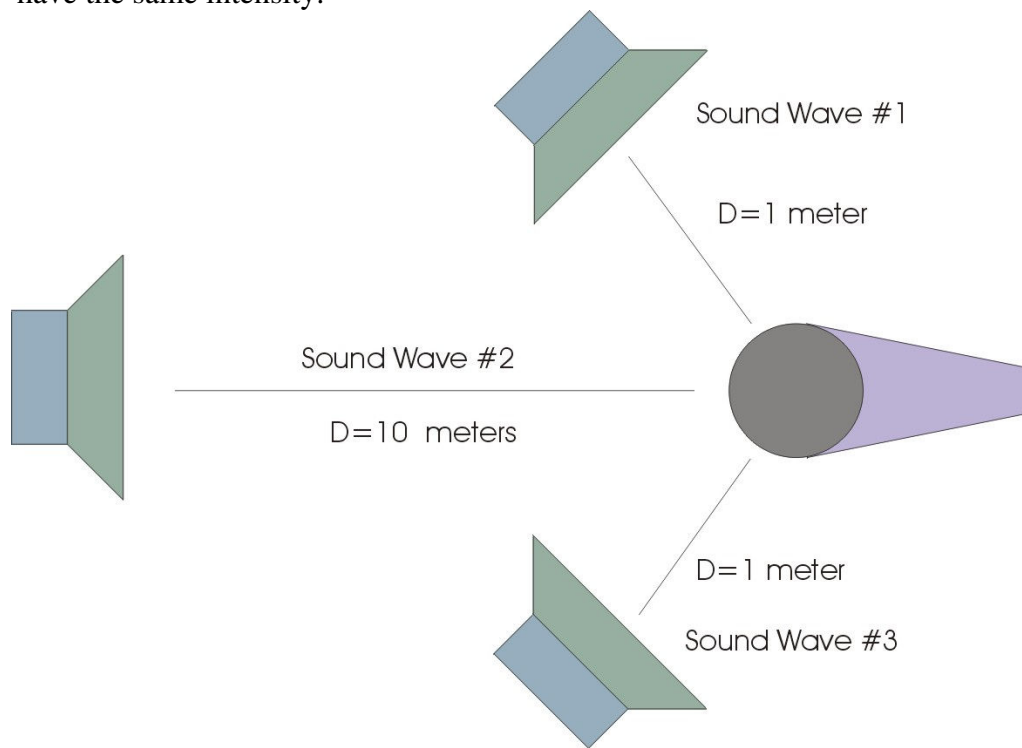
1) What are the frequencies and the intensities of these waves?

F sound-wave #1: _____ Hz Intensity: _____ Volts

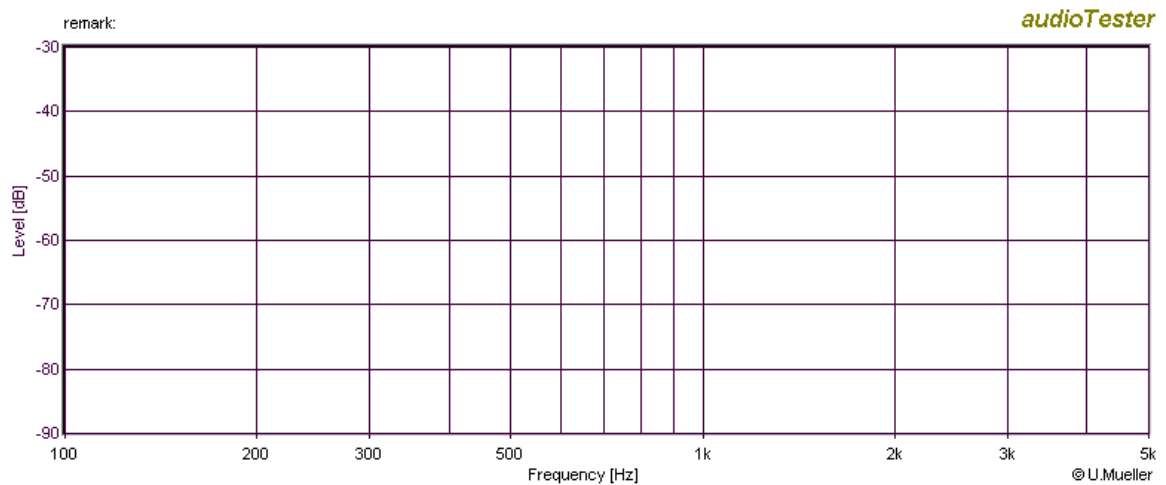
F sound-wave #2: _____ Hz Intensity: _____ Volts

F sound-wave #3: _____ Hz Intensity: _____ Volts

2) The sound of these three sound waves is produced by three speakers placed as shown in the following diagram. The original waves produced by the speaker have the same intensity.

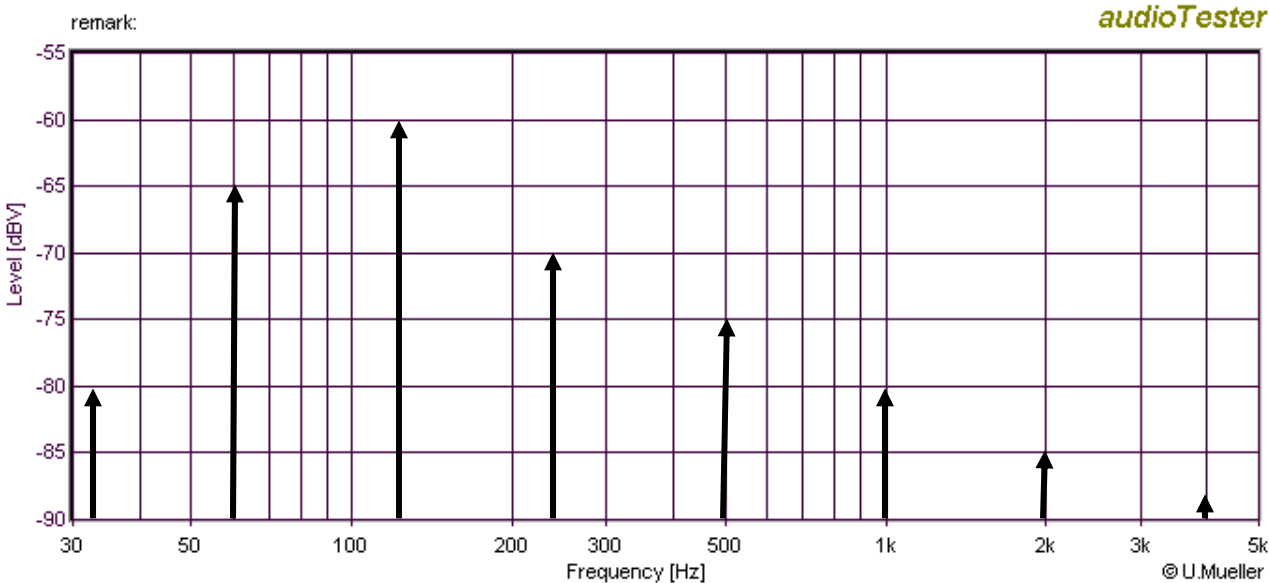


Plot **qualitatively** the output of the microphone on the following spectrum analyzer screen (pay attention to the distance from the speaker to the microphone)



Question # 5 (29 points)

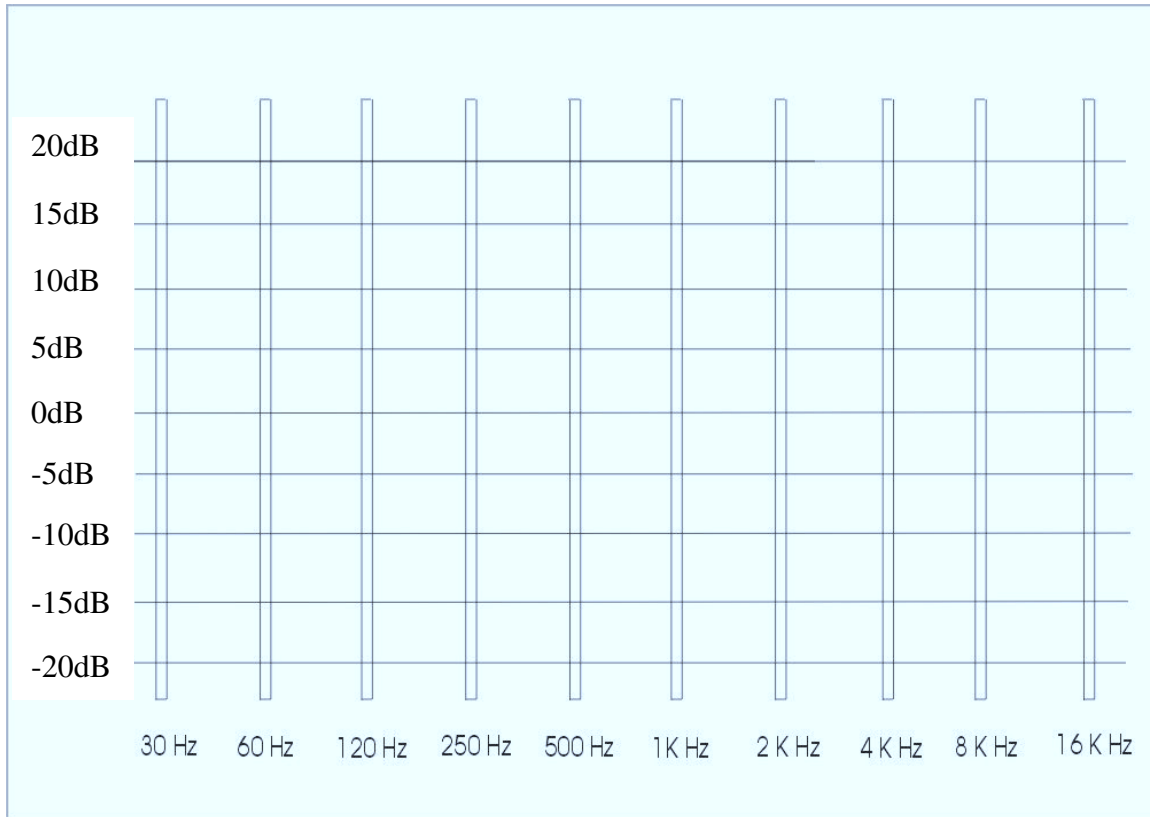
Given the following sound signal (represented on the spectrum analyzer screen) supplied to the input of the equalizer



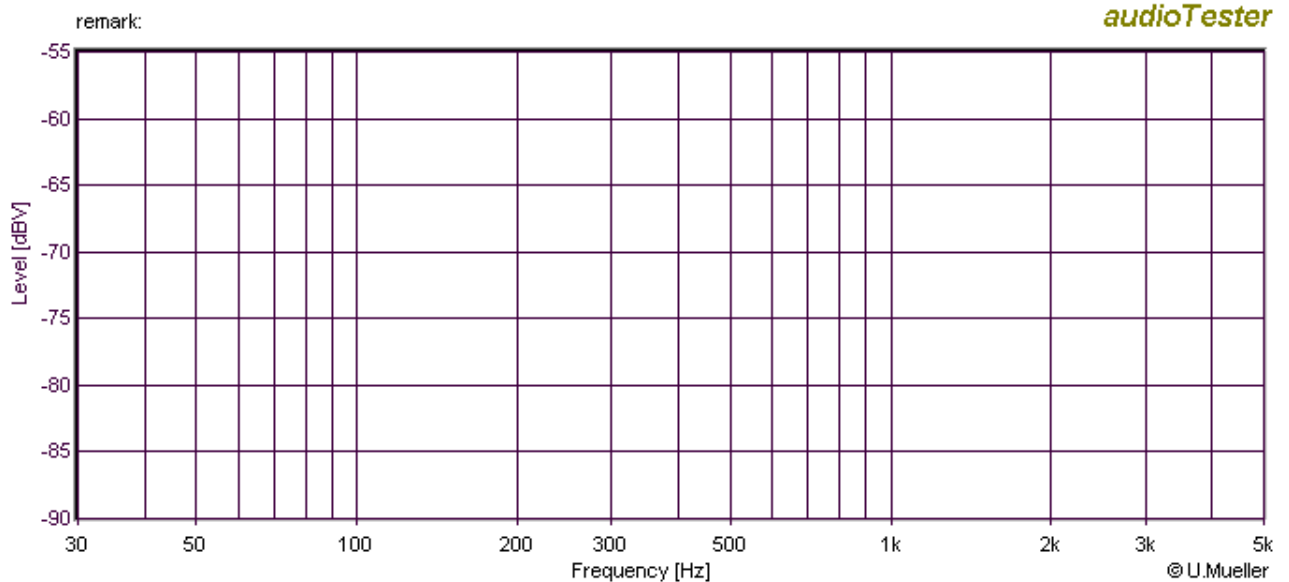
a) Record all the frequencies displayed by the Spectrum Analyzer screen, and their amplitude in the following table

Frequency [Hz]	Amplitude [dBV]

- b) Set up the controls of the equalizer showed below to provide an output signal in which all the present frequencies will have the amplitude close to -70 dBV. Mark the position of the slide on the picture presented below



- c) Draw the output of the equalizer after your setting



Columbia College Chicago

The Science and Mathematics Department

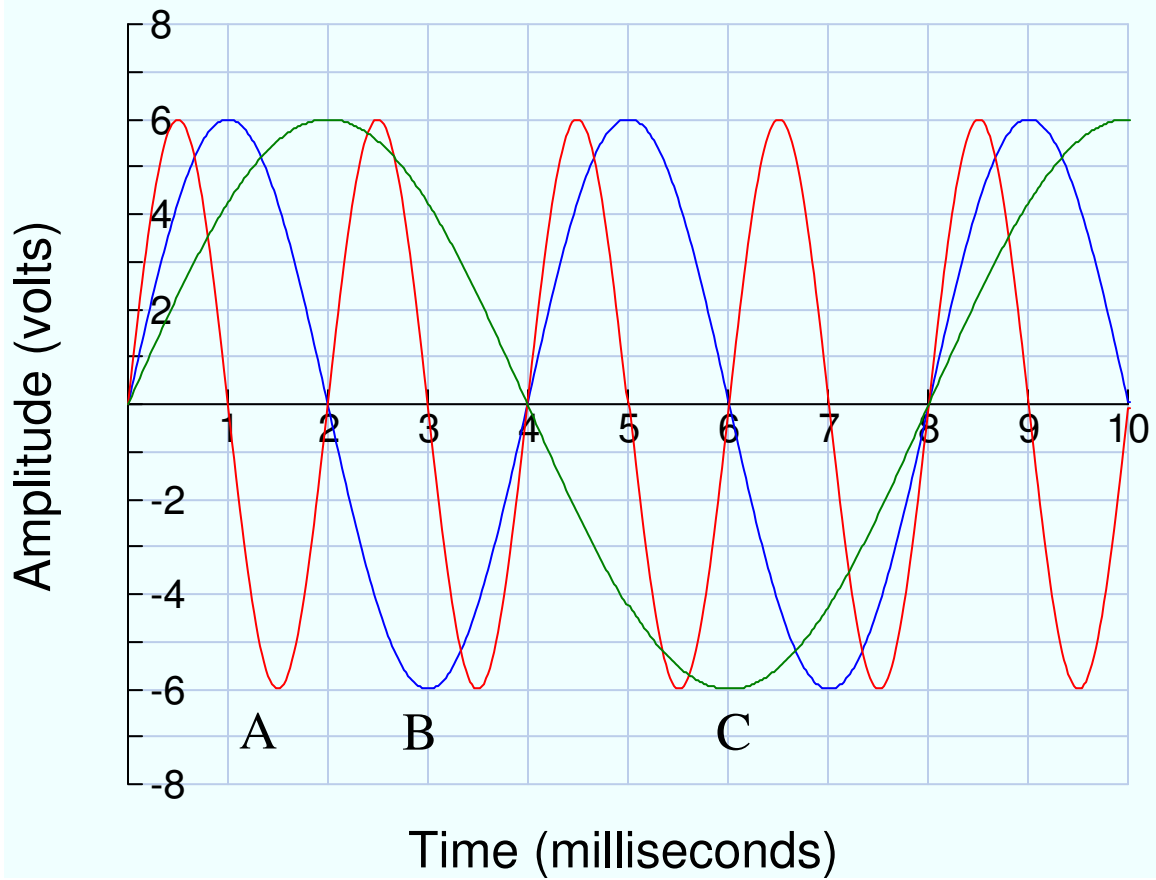
Science and Technology in the Arts

Course # 56-1681

Final Examination

Name of the Student	
Date	

Question #1 (2 points)



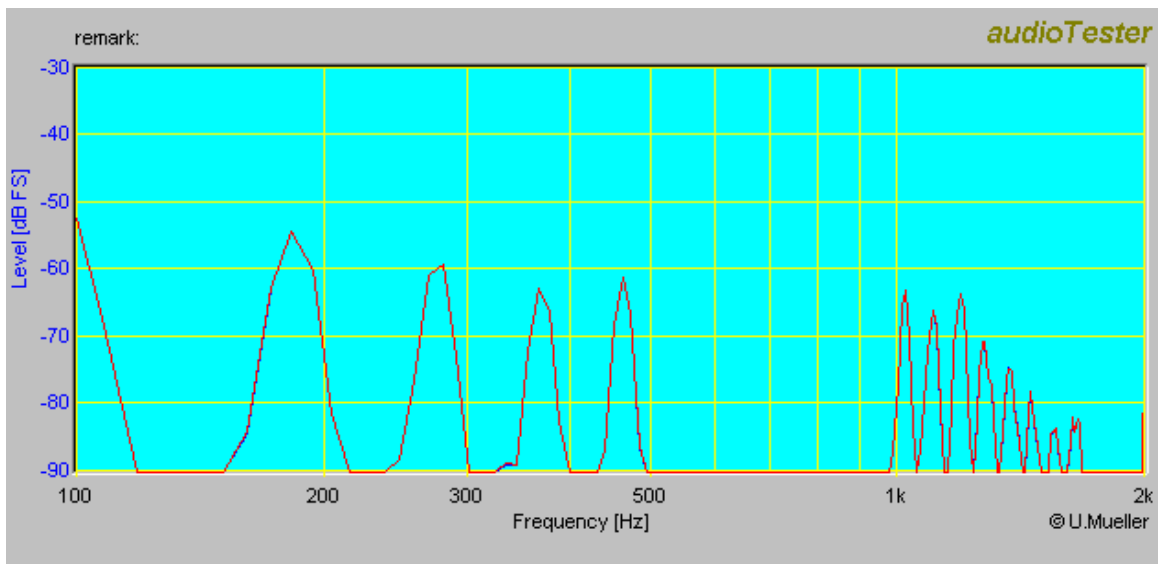
According with the oscilloscope screen of the three sound waves A, B, and C, presented above determine:

a) (1 points) Which sound wave is the louder?- Justify your answer

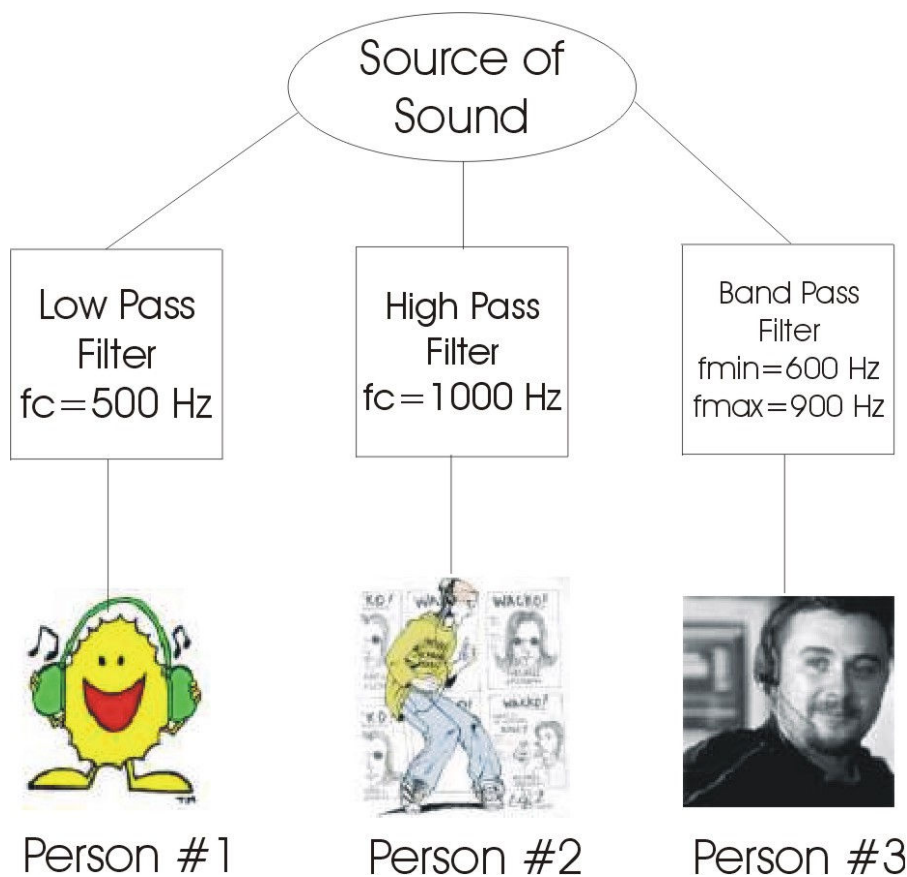
b) (1points)Which sound wave has the lower frequency? – Justify your answer.

Question #2 (6 points)

An unidentified source of sound is described by its spectrum analyzer screen presented below



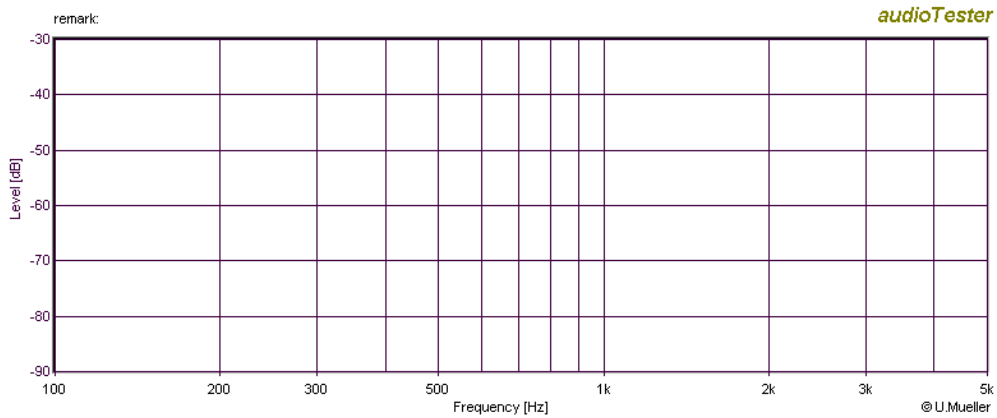
There are three people in the room, each one of them will hear the sound through a set of headphones, after the sound passed through an specific filter as shown in the picture below



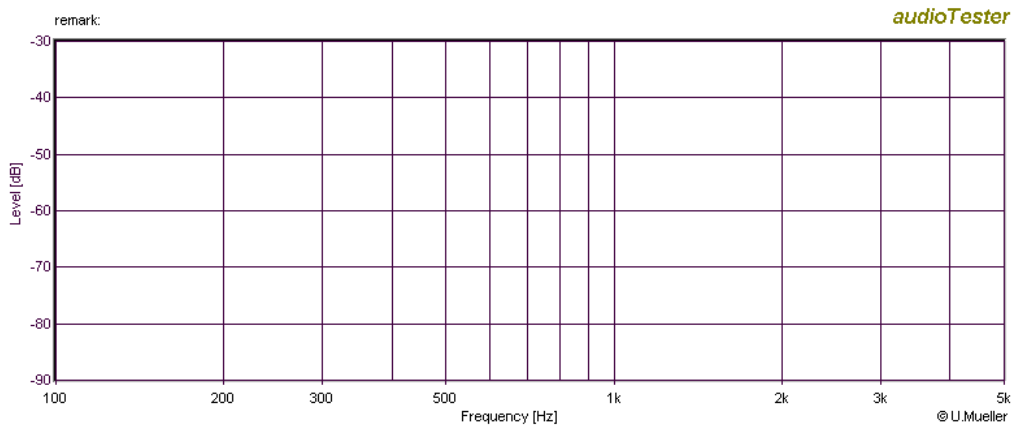
Draw in the spectrum analyzer screen presented below

The frequencies each one of the listeners are hearing (frequency and intensity)

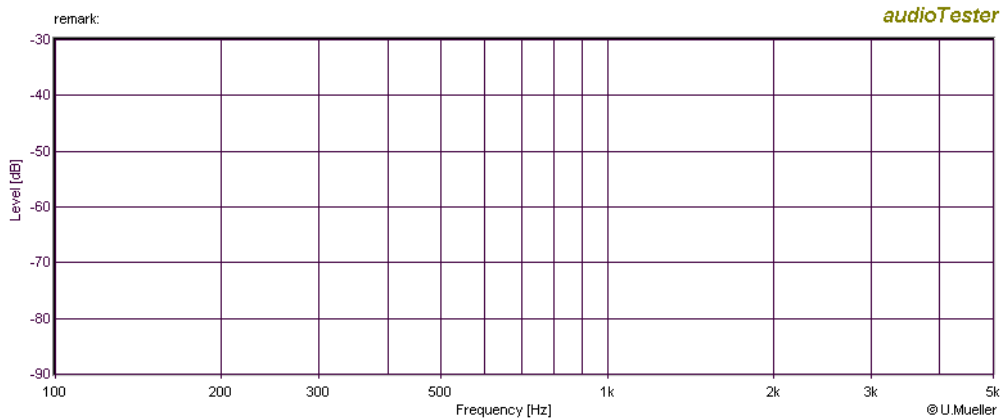
(2 points) a) **Person #1**



(2 points) a) **Person #2**

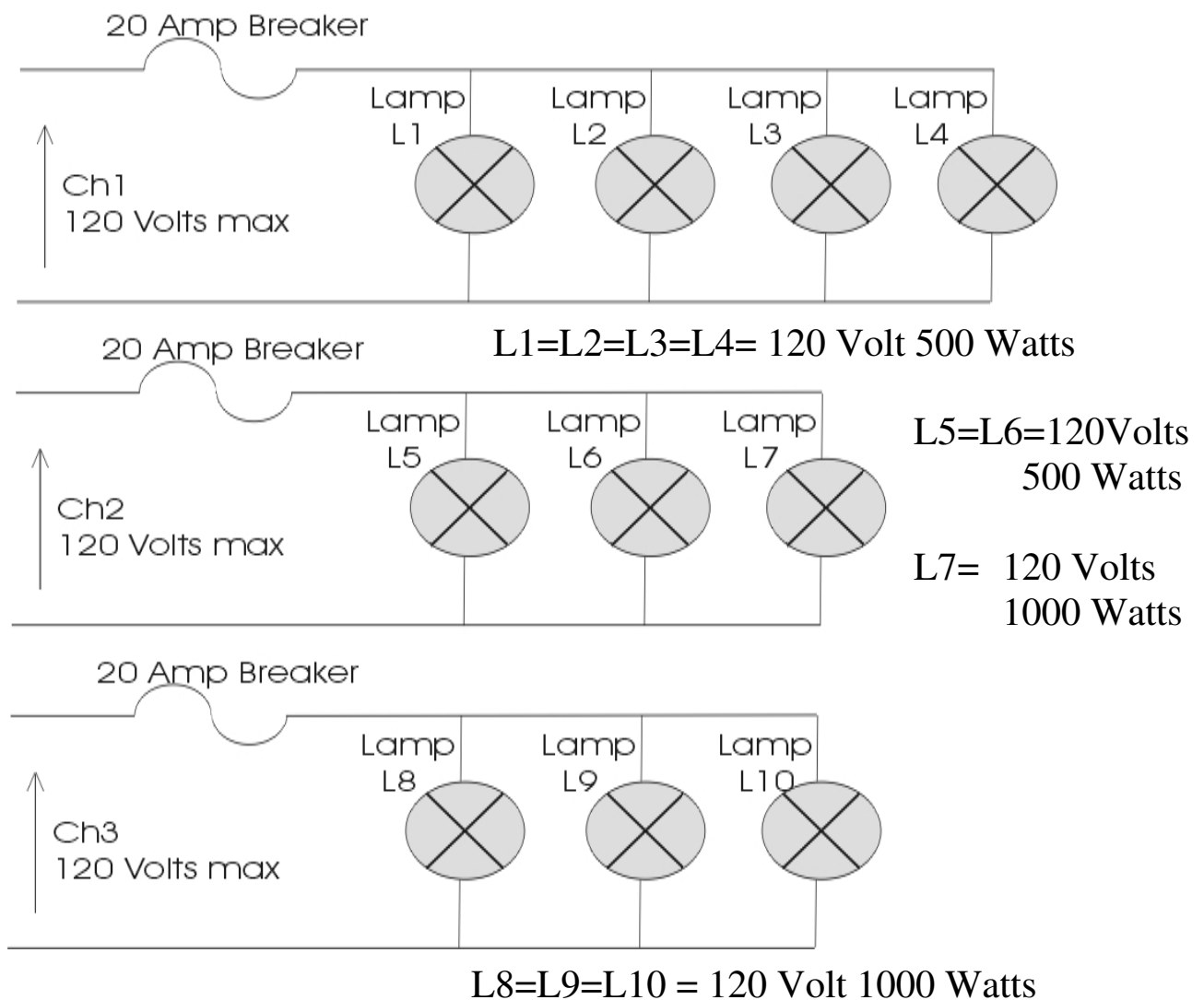


(2 points) a) **Person #3**



Question #3 (25 points)

- 1) (3 points) Explain briefly how a dimmer controls the intensity of light of the lamps.
- 2) (4 points) Research for a dimmer used in artistic performances, print its data sheet and explain their major features (at least 5 – add a page with your explanations).
- 3) (18 points) You are given a dimmer with three channels. Each channel has a breaker of 20 amperes and a nominal voltage of 120 V. Each channel has a different configuration of lamps connected as shown in the following diagram:



- a) Is the breaker of Channel 1 supporting the load? (Amount of current).
Yes/No, justify your answer with calculations.
- b) Is the breaker of Channel 2 supporting the load? (Amount of current).
Yes/No, justify your answer with calculations.
- c) Is the breaker of Channel 3 supporting the load? (Amount of current).
Yes/No, justify your answer with calculations.
- d) The lamp L10 is removed from Channel 3 and replaced by a lamp called **L10New** of 300 Watts. In this new configuration, is the breaker of Channel 3 supporting the load? (Amount of current). Yes/No, justify your answer with calculations.

e) What is the total power that the lighting system needs when all ten lamps L1 to **L10New**? Are the lamps working at their nominal features? Yes/No, justify your answer.

f) What is the total current that the dimmer supply to the lighting system?

Bonus (10 points)

You arrived to the theater to prepare the lighting system for a performance and find the following materials are available to use:

One dimmer with two channels: Channel 1 and Channel 2. The features of each channel are identical: 120 Volt, 3000 Watts

Lamps

4 lamps of 120 Volts, 500 Watts

2 lamps of 60 Volts, 300 Watts

3 lamps of 40 Volts, 400 Watts

2 lamps of 120 Volts, 800 Watts

Draw the connection of the lamps to the dimmer in the way that all the lamps are lighting in their nominal features, and prove that the breakers of the dimmer will not open when using it to its nominal voltage.

Explain your connections and justify your selection using the appropriated calculations.

Add pages as needed

Question #4 (12 points)

Given the following different kind of spots:

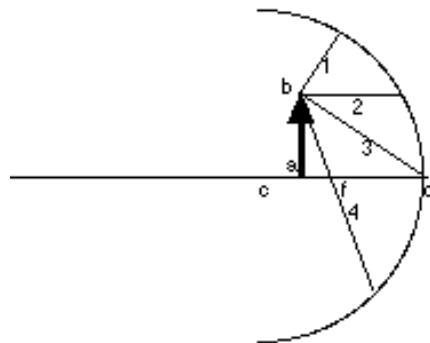
Plano Convex
Ellipsoidal Reflector
Fresnel
Par64
Beam projector
Followspot

- 1) Describe **briefly** (Do not copy) the characteristics features of each one of the mentioned spots.
- 2) Describe the typical application of each one of the spots when used to illuminate artistic performances

Note: one possible reference <http://www.mts.net/~william5/sld/sld-500.htm>
(Please add pages as needed to provide the answer to this question)

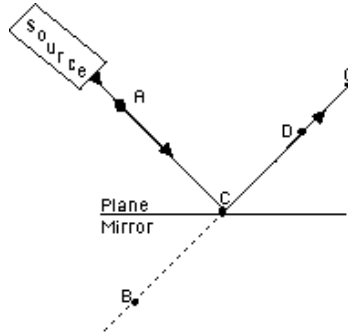
Question #5 (25 points) Multiple choice – Circle the right answer

- 1) (2 points) The diagram shows four rays of light from the object ab incident upon a spherical mirror. Point f is the principal focus of the mirror, point c is the center of curvature, and point o is located on the principal axis. Which ray of light will pass through f after it is reflected from the mirror?



1) ____ 2) ____ 3) ____ 4) ____

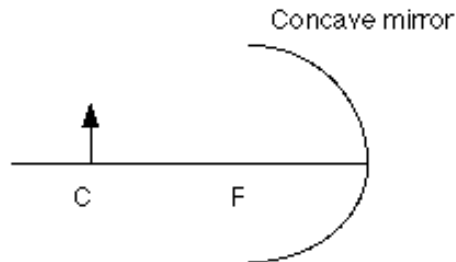
- 2) (2 points) In the diagram below, a source produces a light ray that is reflected from a plane mirror.



To an observer at point O , the light appears to originate from point

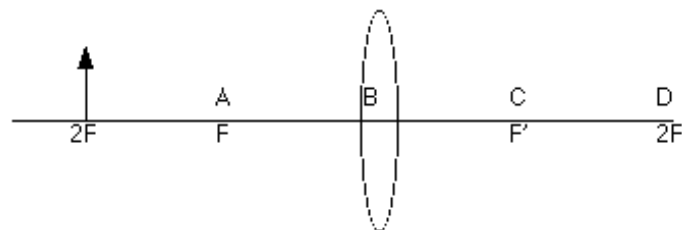
- A) ____ B) ____ C) ____ D) ____

- 3) (2 points) As the object is moved from point C toward point F , the size of its image



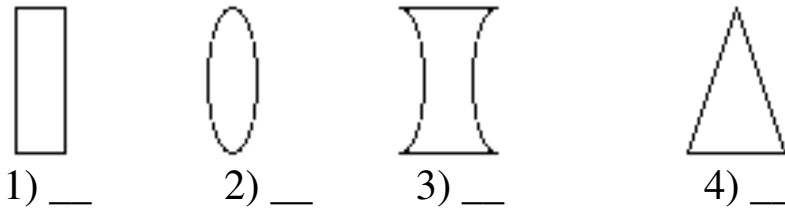
Increases: ____		Decreases: ____		Remains the same: ____	
-----------------	--	-----------------	--	------------------------	--

- 4) (2 points) The diagram represents an object placed two focal lengths from a converging lens. At which point will the image be located?

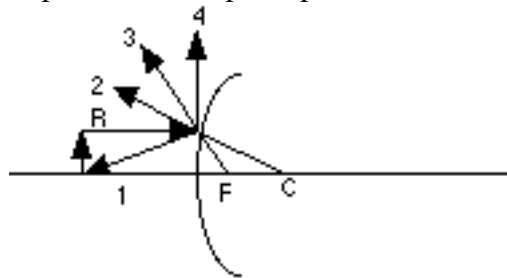


- A) ____ B) ____ C) ____ D) ____

- 5) (2 points) Which piece of glass could be used to focus parallel rays to a small spot of light?

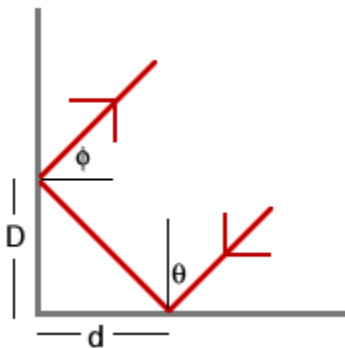


- 6) (2 points) In the diagram below, an object is located in front of a convex (diverging) mirror. F is the virtual focal point of the mirror and C is its center of curvature. Ray R is parallel to the principal axis. Which ray is its reflection?



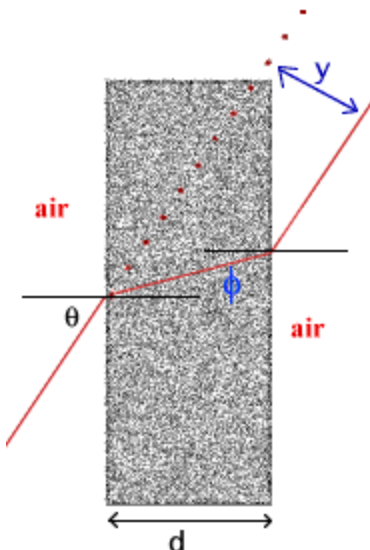
1) 2) 3) 4)

- 7) (2 Points) A light ray strikes a horizontal mirror and is reflected onto a vertical mirror. If $\alpha = 30$ degrees and $d = 1.57$ meters, what to the nearest degree is β ?



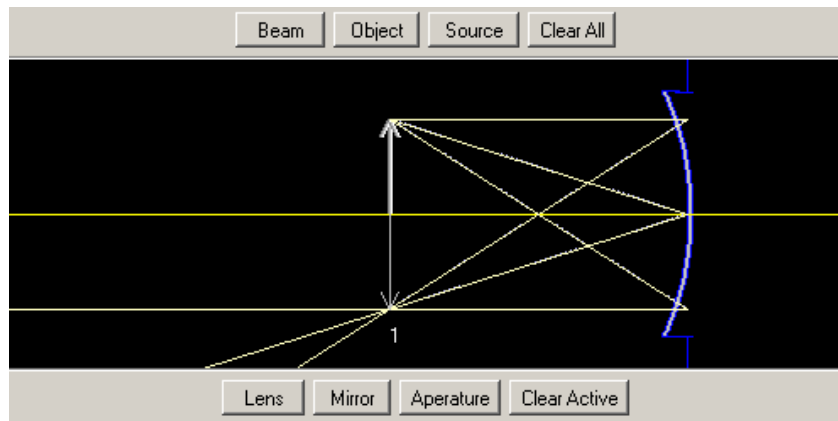
- a) 25 degrees
- b) 30 degrees
- c) 35 degrees
- d) 45 degrees
- e) 60 degrees

- 8) (2 Points) In the figure $\alpha = 70$ degrees and the index of refraction of the 'glass' is 1.42. To the nearest degree what is β ?



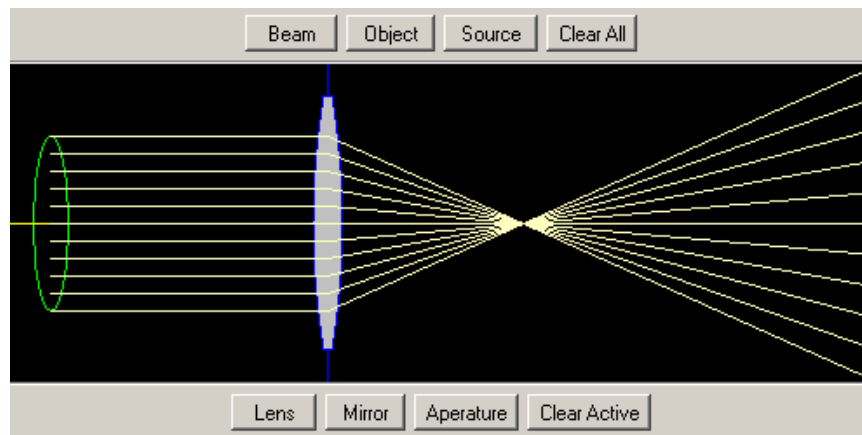
- f) 39 degrees
- g) 41 degrees
- h) 43 degrees
- i) 49 degrees
- j) 51 degrees

9) (2 points) Given the following ray diagram. On which point of the axis of symmetry is the object placed?



- a) Focus
- b) Center of curvature
- c) Between the focus and the Center of Curvature
- d) Faraway from the center of curvature

10) (2 points) Given the following ray diagram for the lens A. Where is needed to place an additional convex lens B to produce a beam of light?



- a) The focus of the lens B is on the vertical axis of the lens A
- b) The focus of the lens B is between the lens A and the focus of the lens A
- c) The focus of the lens B is on the same place of the focus of the lens A
- d) The focus of the lens B is faraway from the focus of the lens A.

Select the answer that will complete the sentence

11) (1 point) With light, high amplitude is perceived as _____

- a) Brightness
- b) Change of color
- c) Contrast
- d) Increased pressure

12) (1 point) With sound, high amplitude is perceived as _____

- 1. Pitch
- 2. Timbre
- 3. Contrast
- 4. Increased pressure

13) (1 point) When a light ray travels through one media and pass to another different media, it will change direction. This phenomenon receives the name of _____

- 1. Reflection
- 2. Refraction
- 3. Interference
- 4. Snell Law

14) (1 point) When a sound wave travels through one media and pass to another different media, it will change direction. This phenomenon receives the name of _____

- 1. Reflection
- 2. Refraction
- 3. Interference
- 4. Snell Law

15) (1 point) Reflection and refraction are physical phenomena that take place _____

- 1. Only with sound
- 2. Only with light
- 3. Only with light and sound
- 4. With any kind of wave

Question # 6 (10 points)

- a) (2 points) A sound wave moves through the air. Its frequency is 522.32 Hz. The air temperature is 11 °C. Calculate to the nearest tenth of a meter per second, the velocity of the sound on air.
- b) (2 points) The frequency changes to 1090.7 Hz. The air temperature reminds 11 °C. Calculate to the nearest tenth of a meter per second, the velocity of the sound on air.
- c) (2 points) The frequency reminds 1090.7 Hz. The air temperature changes to 45 °C. Calculate to the nearest tenth of a meter per second, the velocity of the sound on air.
- d) (2 points) To what conclusion you can arrive based on the calculations of the parts a), b) and c)
- e) (2 points) Given the following data collected about the velocity of the red light (650 nm) and green light (510 nm) on air.

$$V_{\text{red}(T=0^{\circ}\text{C})} = V_{\text{green}(T=0^{\circ}\text{C})} = V_{\text{red}(T=11^{\circ}\text{C})} = V_{\text{green}(T=11^{\circ}\text{C})} = V_{\text{red}(T=45^{\circ}\text{C})} = V_{\text{green}(T=45^{\circ}\text{C})}$$

What are your conclusions comparing the effect of the temperature and frequency on sound and light velocities? Justify your answer based on the data presented and the physics of sound and light.

Question # 7 (20 points)

Given the following systems



Parabolic Microphone



Solar Cooker

Explain the scientific principles behind the operation of each of the systems.

a) (6 points) Describe, (use graphs and draws to clarify your description), how the parabolic microphone works. Explain where the position of the microphone will be to achieve the optimal performance of the system.

b) (6 Points) Describe, (use graphs and draws to clarify your descriptions), how the solar cooker works. Explain where the position of the meal to be cook will be to achieve the optimal performance of the system.

c) (8 points) What are your conclusions about Light and Sound. Justify your answers based on your answers to the previous questions.

Science and Technology in the Arts

Marcelo Caplan, Instructor

COURSE EVALUATION Spring 2009

Express Yourself

Suppose you are writing a letter to a friend concerning your experiences in the Science and Technology in the Arts course you are completing this semester. This letter should address the nature of the physical content, course requirements, the labs activities, the type of teaching techniques employed, a comparison of this course to any other science course you have taken in college or high school and the instructor.

In addition please remark if you would recommend this course and/or the instructor to your friend or other students, and if you would enroll in any other course offered by the instructor regardless the subject area

DO NOT SIGN YOUR NAME !!!!

Date: _____

Dear _____

Science and Technology in the Arts

56-1681-01 (SL), Fall 2009

Department of Science & Mathematics
Columbia College Chicago
600 South Michigan Avenue
Chicago, Illinois 60605

Course Title: Science and Technology in the Arts
Document date: Fall 2009
Course Number: 56-1681
Section Number: Section 01
Credits: Three credits
Designation: SL
Meeting Days and Times: Tuesday 9:00 am – 11:50 am
Meeting Location: 623 South Wabash – Room 504

Instructor Name: Marcelo Caplan
Office location: 624 South Michigan Room 1400 I
Office phone: 312-369-7989
Email address: mcaplan@colum.edu
Mail delivery: Mail may be brought to room 500 of the 623 South Wabash building and given to the student worker for delivery to my mailbox.

Departmental office: 623 South Wabash, room 500
Departmental phone: 312-369-7368
Departmental fax: 312-369-8075
Availability: Tuesday 1:00 pm to 2:00 pm or by appointment

Required Text(s): **Scene design and stage lighting**
By W. Oren Parker and R. Craig Wolf
8th Edition (2003)
Harcourt Brace College Publishers
ISBN: 0-15-501620-2

Other required materials: Flash drive (256 Mb minimum).

Recommended supplemental texts: Supplementary reading materials will be posted on the OASIS page for this class

Course fees: \$40.00

Course Description:

Students explore technologies that are used in the production of artistic performances and the scientific principles behind them. These technological systems include audio, lighting and mechanical (robotics) control. Students investigate the properties of sound and light through a series of hands-on experiments and design scale model systems such as a public address system, lighting and computerized stage controls. Students gain experience on the potential application of technological resources to improve their own creative production.

Course Rationale:**Content Introduction**

This course is designed to give students an introduction to the fascinating world of the technological systems used to enhance artistic performances, understanding the scientific principles that rule their operation, and the technological implementation at the performance time. During the course, students will explore the processes involved the auditory and visual senses, and how the application of scientific and technological knowledge, will contribute to enhance the final performance.

We will first explore the characteristics of the sound phenomena, and how technological audio systems come to aid to improve the quality of the production and reproduction of sound. We will then delve into the proprieties of light and color, how to produce light and how to control its intensity using electricity as the source of energy.

The development of critical thinking and the understanding of the scientific method is an inherent part of the learning process. In the class, students will be involved in a series of hands-on experiments to discovery, using inquiry method, scientific concept, and derivate technological applications through their own conclusion. Students will be challenged to solve real situations using the knowledge acquired in the course.

Students will demonstrate the gain in scientific knowledge and technological skills through different assessments such as: labs reports, tests (mid term and final exam), and the preparation and presentation of a special project, in which student will express in their terms, what they learn in the course, based in the media preferred by the students, and their personal background.

This course satisfies the Science with lab requirement of the Liberal Arts and Sciences Core Curriculum.

Prerequisites: None

General Science Objective: Students will develop basic scientific literacy, understand the scientific method of inquiry and appreciate the impact of science on society.

Learning Outcomes

Goal:

This course will introduce students to different technological systems that are related to artistic production, and the scientific principles behind these systems. Students will gain an understanding of the systems used in the real world, how they work, and how to achieve their maximum output under safe conditions.

Objectives:

During the completion of this course the student will:

- Be introduced to technological systems that are used in the production of artistic performances;
- Explore through hands-on experiments several technological systems and the scientific principles behind them (including aspects of electricity, light and sound);

At the successful completion of this course the student will:

- Understand scientific principles of electricity, light and sound.
- Develop technical skills that will facilitate the integration of technological resources into an artistic production (including sound, light, special effects, etc) and;
- Develop problem-solving skills that will allow students to solve problems that will arise in the implementation of productions

Grading and Evaluation: Your final grade will be assigned using the scale below:

A-	90-92	A	100-93		
B-	80-82	B	83-86	B+	87-89
C-	70-72	C	73-76	C+	77-79
		D	60-69		
		F	Below 60		

Evaluation

3 Quizzes:	20 %
Final Exam (take home):	20 %
Final Project:	35 %
Participation in class/ Lab Reports:	25 %

Exams:

During the semester will be three quizzes and one final exam covering previous material. The quizzes will be an open book examination. Students will be allowed to use their notes and book. The final term examination will be a take home exam. The students will receive the exam in the 14th week of the semester. The students are given one week to complete and return the exam.

Final Project

Students are expected to present a project that deals with the material covered during the semester. They are encouraged to combine their major, interests, and cultural background to communicate topics covered in class during the semester. Students will be asked to present their project to the class and share with them the ideas and the process that conducted to the creation of the project.

It is important to remark that the project will be evaluated according to scientific accuracy and relevance. Students are encouraged to unleash their creativity, all the time their project is scientifically correct.

Lab Reports

Lab reports are an important part of student grade. During the semester, we will have about 8 - 10 hands-on experiments. The lab reports will be presented in a template format. The students will edit the lab reports, include the data collected from the experiment, answer the questions and developing their conclusions based on the data generated during the experiment.

Attendance Policy: Missing class will have an adverse effect on the learning process and on your course grade.

Late Work and Makeup Policy: Labs reports are due one week after the laboratory experiment is completed. If you miss a lab, is your responsibility to inquire about the possibility of a make-up session.

Academic Integrity: Students at Columbia College enjoy significant freedom of artistic expression and are encouraged to stretch their scholarly and artistic boundaries. However, the college prohibits all forms of academic dishonesty. For present purposes, "academic dishonesty" is understood as the appropriation and representation of another's work as one's own, whether such appropriation includes all or part of the other's work or whether it comprises all or part of what is represented as one's own work (plagiarism).

Appropriate citation avoids this form of dishonesty. In addition, "academic dishonesty" includes cheating in any form, the falsification of academic documents, or the falsification of works or references for use in class or other academic circumstances.

When such dishonesty is discovered, the consequences to the student can be severe.

(Taken from the Columbia College Chicago Student Handbook.)

Services for Students with Disabilities: If you need accommodations in this course, due to a disability, please notify me so that I can verify that the required documentation is on file with the Office of Services for Students with Disabilities (SSD) and that your accommodation plan is in place. If you do not currently have a plan with the SSD Office, please contact The Assistant Director of Services for Students with Disabilities, Sandra Saunders, at (312) 369-8134 or go to the SSD Office located at 623 S. Wabash Avenue, Suite 304 in order to create a plan for accommodation of your disability. Accommodation letters are required in order for accommodations to be provided.

Science and Math Learning Center: The Science and Math Learning Center, located at the 618 South Michigan building, provides free individual and group tutoring sessions. Faculty tutors are certified and qualified instructors in the areas of Science and Math and are available Mondays through Thursdays from 9am to 7pm, Fridays from 9am to 5pm, and Saturdays from 12pm to 3pm. Appointments and walk-ins are welcome. For further information call (312) 369-7730.

Course Calendar (tentative):

Class #	Description
One	<p>Course overview</p> <p>Introduction:</p> <p>Discussion: The relation between science, technology and the arts</p> <p>What is Science?</p> <p>What is Technology?</p> <p>Which human senses are stimulated when you participate in a performing art presentation?</p> <p>Which human senses are stimulated when you participate in a fine art presentation?</p> <p>Introduction to the Scientific Method and harmonic motion</p> <p>Experiment #0: The relationship between the length of the string and the period of the pendulum</p>
Two	<p>Introduction:</p> <p><i>What is sound?</i></p> <p>Sound as mechanical energy moving through a medium.</p> <p>Wave theory:</p> <p>Definition and Proprieties of waves: Period, amplitude, frequency, wave length</p> <p>Relation between frequency and pitch, intensity and loudness.</p> <p>Introduction of the concept transducer: The microphone as a mechanical / electrical transducer and the Speaker as an electrical/mechanical transducer.</p> <p>Experiment #1:</p> <p>Visualization of a sound wave using an Oscilloscope.</p> <p>Determine the characteristics of different sound waves using the oscilloscope.</p>
Three	<p>The velocity of sound and its relation with the frequency.</p> <p>Does the sound traveling at different velocities for different frequencies?</p> <p>Experiment #2:</p> <p>Determine the relationship between the velocity of sound and its frequency</p> <ol style="list-style-type: none"> 1. Using a resonant tube 2. Using an electronic Audio system <p>How the velocity of the sound and the characteristics of the room could influence in the quality of the sound in a room?</p> <p>Constructive and destructive interference</p>

<p>Four</p> <p>Reading Seven Ed Pg 346-354</p> <p>Eighth Ed. Pg.315-328</p> <p>Shure notes</p>	<p>The general audio system: General parts of an Audio System: Inputs (microphones, record player, etc), Mixer, Equalizer, Amplifier, and Speakers</p> <p>Microphones: an analysis of different kind of microphones: dynamics, condensers, wireless Explanation of the scientific principles of a microphone Dynamic microphone: Relation between magnetism and electricity – Lenz law. Building a microphone with a magnet and a coil.</p> <p>Condenser microphone: Introduction to electrostatics - Relation between the change in the electrical charge between two plates and the distance between them.</p> <p>Experiment #3: Using different microphones, investigate the intensity of the sound in function to the distance from the source.</p>
<p>Five</p> <p>Reading Seven Ed. Pg 360-364</p> <p>Eighth Ed. Pg.331-335</p>	<p>Why do different instruments produce different sounds? The sound as a combination of multiples waves – Harmonic series</p> <p>Experiment #4: Sound as a combination of multiple waves</p> <p>Speaker: Explanation of the scientific principles of a speaker. Analysis of different speakers for the reproduction of different frequencies.</p> <p>The Audio Amplifier: Description of its task, and how it works,</p> <p>Calculation of gain of an Amplifier, The decibel (dB) notation of gain and power.</p>

<p>Six</p> <p>Reading Seven Ed. Pg 358-360</p> <p>Eighth Ed. Pg.331-332</p> <p>Filters note</p>	<p>The general audio system (continuation):</p> <p>The Equalizer: Description of its task, and how the equalizer works,</p> <p>Introduction to filters: low pass filter, high pass filter, band pass filter and the concepts of cutoff frequency, center frequency and passing bandwidth. Learning how the filter works through computerized simulation</p> <p>Experiment #5: How an equalizer works How the graphic equalizer changes the timbre of the incoming sound?</p> <p>Demonstration: Investigating the response of an equalizer to different frequencies using a virtual wave simulation to produce a sound composed by several known harmonics; the spectrum analyzer to check the effect of the equalizer on the composed wave.</p>
<p>Seven</p>	<p>The Mixer: Description of its task, and how the mixer works</p> <p>Demonstration: Implementation of a typical audio system including several sources of sound.</p> <p>Project #1: Building an audio system using the TED kits: Determine the gain of the power amplifier and the frequency response of the audio system.</p>
<p>Eight</p>	<p>Introduction to electronic sound generation and reproduction. From the performer to the CDROM Introduction to the digital and analog world. Analog to digital conversion of sound - Storage of sound in computers or CDROM. Digital to analog conversion - Reproduction of the sound from the digital systems. Using a computer to record, modify and reproduce sound</p>

<p>Nine</p> <p>Reading Seven Ed. Pg 373-378 Pg 396-398 Pg 580-595</p> <p>Eighth Ed. Pg 344-350 Pg 388-395 Pg.550-566</p>	<p>Introduction: What is light? Different sources of light The proprieties of the light waves: a comparison between light and sound waves.</p> <p>Production of light: Definition of light intensity. Different lamps and their work principles: incandescent, fluorescent, halogen, and voltaic arc</p> <p>Experiment #7 Determine the relationship between the intensity of light and the distance from the light source.</p> <p>Introduction of the electrical concepts: Voltage, Current, and Power</p>
<p>Ten</p> <p>Reading Seven Ed. Pg 560-570</p> <p>Eighth Ed. Pg.530-546</p>	<p>Basic Electricity on the stage</p> <ul style="list-style-type: none"> • Measurement of Voltage and Current • Definition of the concept Resistance – Ohm Law • Calculation of Power <p>Using more than one lamp – How to connect them? Serial and Parallel connection and its implications related to voltage, current and power limitations.</p> <p>Experiment #8: Comparison between series and parallel connection</p> <p>Understanding the limitations of electrical equipment (Current and power limitations) Introduction to fuses and breakers.</p>
<p>Eleven</p> <p>Reading Seven Ed. Pg 436-457</p> <p>Eighth Ed. Pg.409-424</p>	<p>Changing the intensity of the light through voltage control – A dimmer Description of its task and how a dimmer works.</p> <p>Experiment #9: The relationship between the intensity of the light and the potential (voltage) applied to the light source.</p> <p>Project #2: Using the TED kits build a dimmer to determine the relationship between the voltage supplied to the lamp and the intensity of the light produced.</p> <p>Presentation of different lighting system used in artistic performances</p>

<p>Twelve</p> <p>Reading Seven Ed. Pg 465-472</p> <p>Eighth Ed. Pg.435-443</p>	<p>Focusing the light on the stage – Introduction to Geometrical optics Definition of object and <i>its</i> image</p> <p>Using mirrors to direct light Reflection, Plane and Spherical mirrors,</p> <p>Using lenses to focus light Refraction, Lenses, Exploring Convergent and Divergent lenses and its proprieties</p> <p>Experiment #10: Investigation of mirrors and lenses</p>
<p>Thirteen</p> <p>Reading Seven Ed. Pg 472-495</p> <p>Eighth Ed. Pg.443-473</p>	<p>Spotlights Introduction of the different spotlight: How they work and their application in artistic performances.</p> <p>Controlling light, sound and movement on the stage Introduction to control systems What is a control system? Components of a control system: Sensors, Controller, Plant Input (desired state) – Product (present state) <i>Open loop and close loop systems</i> Project #3: Building a Intensity of light control system using the TED kits</p>
<p>Fourteen</p>	<p>Computerized control The role of the computer in a control system How the computer does activate devices in the real world?, Interfaces Introduction to computer interfaces Different input-output systems</p> <p>Digital and analog How the computer knows what to do? , Programming. Introduction to programming using flow chart and simple operations: set, if, go to Exercises (programming and implementation in the class): Controlling lights Designing a traffic light</p>
<p>Fifteen</p>	<p>Return Final Exam and presentation of projects.</p>

Disclaimer Statement: This syllabus may be amended as the course proceeds. You will be notified of all changes.

Guidelines for the generation of the *Definition of the Project* document

General Overview

To ensure that the project will fulfill the requirement of the class, students will produce a document, *Definition of the Project*. The document will be submitted for formal approval by the instructor, and may be revised by the instructor to ensure alignment with the requirements of the class. After the instructor's approval is obtained, the *Definition of the Project* document will serve as a "contract" between the student and the instructor concerning the students' responsibilities in the production of the final product.

The *Definition of Project* document will include the following components:

1. Definition of the self-selected topic
2. Definition of the breadth and depth of the concepts to be developed in the project
3. Conceptual map of the project
4. Definition of the rubric to evaluate the project
5. Definition of the media to present the project

Following are detailed descriptions of each of the components of the *Definition of the Project*. At the end of the detailed descriptions, you will find an example of a *Definition of the Project* document that is presented to illustrate each of the components.

Definition of the scientific content

1) Definition of the self-selected topic

You will select a topic of your choice from the syllabus of the class, Science and Technology in the Arts. To ensure that the selected topic is broad enough for the final project, your selected topic will address topics that cover at least six class hours (two meetings) of lecture/laboratories content and activities. If you prefer to explore concepts and ideas that were *not* covered in the course syllabus, you must schedule a discussion with the instructor to obtain formal consent for the deviation.

2) Definition of the breadth and depth

After you select a topic, you will define which concepts within the selected topic will be developed in your project, and will specify the depth to which each one of these concepts will be developed. One requirement for the project is that the concepts presented will be taken to a level above and beyond that which was encountered in the course material. In other words you are expected to expand on the material covered during the semester, and not merely make a glorified presentation of the instructional material used in the classroom. An additional requirement is for each concept introduced into the project will be demonstrated by introducing a technological application.

3) Conceptual map of the project

Students will develop a conceptual map to ensure that there is a coherent relationship among the topic and the concepts, and that the project will be more than a collection of facts.

For more information about concept maps
<http://classes.aces.uiuc.edu/ACES100/Mind/CMap.html>

4) Definition of the rubric to evaluate the project

As presented in the syllabus of the class, the purpose of the final project is to facilitate your own presentation of knowledge you gained during the class—by completing a project to present your self-selected topics using a self-selected media to other students in a manner that will enrich their knowledge of the content learned in class.

The project will be evaluated primarily on the scientific accuracy and relevance of the content presented. However, you are encouraged to unleash your creativity, for the purpose of effectively communicating scientifically accurate perspectives and knowledge throughout the presentation.

To ensure that the evaluation of the project is valid and reliable, you will identify the concepts in breadth and depth upon which you will be evaluated, and insert that personalized information into the rubric below.

The rubric contains three main areas:

- **Concepts addressed in the project:** in this case the rubric will ask if the topics, content and sub-contents defined in the project are presents in the final product presented.
- **Depth of the material coverer in the project:** in this case, the rubric will ask if each concept was illustrated accurately and completely during the project; (below, at least or above the level presented in the classroom), and whether a technological application was illustrated in the presentation. (This section has three parts: accuracy and completeness of concept addressed; technological application; and at/or/above presentation level of class.)
- **Technology applications of the presented concepts:** in this case the rubric will ask if there are presented in the project technological applications of the presented concepts
- **Scientific Communication:** in this case the rubric will ask about the potential for the project to communicate the scientific information to future students observing your project.

Use the example of the rubric presented at the end of this document as a template to personalize the rubric to your own concepts. The bold type indicates those places in which you should insert your own concepts.

5) Definition of the media to present the project

After considering all of the above components, you will declare which media you will use to present your project. You have the freedom to choose the media that better suit your interests, such as film, theatre, dance, music, etc. Students are not required to present their projects in a media that involve their major or concentration. Remember, the goal is to produce and communicate completely and accurately the scientific concepts you have selected.

Specify which media you will use to implement your project as along with an explanation about how using the selected media will convey the targeted concepts. Your planned procedure for using the media needs to be discussed with the instructor to ensure the feasibility of the project within the time limitation situation in the classroom.

Although this is a self-directed assessment, and your artistic involvement is valued, the instructor will give you guidance to minimize the possibility that you will lose site of the goal and/or intention of the project. The instructor does not intend to control or influence the way you will implement their project, but rather intends to ensure that what you propose is feasible under the time and resources limitations of the class.

FINAL NOTE: Time Restrictions

This project can be designed to enhance your portfolio by developing a presentation that could be use during interviews for a position. Therefore, a seven-minute limit is imposed on the final product, including time to present yourself to your audience. This time limitation will not only ensure that class presentations can be accommodated, but will also result in a product reasonably shared with a future employer during the interview process. Some suggestions for using time efficiently include the following:

- If your project includes a life performance, videotape the performance. This way you have control over the time limitation *and* you have documentation of your performance to include in your portfolio.
- If your project includes fine arts, produce an electronic document of your final product. In this way will be easier for your audience to watch the projects as well as you have an electronic product that you can incorporate in your portfolio.

Generation of the Definition of the Project document

Based in the definitions presented above students will generate a document that will include the scientific and technological topic selected, the concepts that will be included in the project, the rubric that will be used to evaluate the project, the media that will be use to present the project and a description of how using the selected media, the selected topic and concepts will be communicated through the project to the audience.

This document will be discussed with the instructor, and amended is necessary to ensure that the project will comply with the requirement for the assessment of the scientific and technological knowledge gained by the students during the class.

Following is an example of the Definition of the Project Document.

Example

Definition of the Project – Example

Title of the project: Controlling the light on the stage

Student Name: Juan Lopez

Date: March 28, 2008

Topic: Controlling Light (weeks 9 to 13 in the syllabus)

Concept #1: Controlling the Intensity of the light by changing the voltage applied to the lamp

Sub-concept#1: Basics of electrical circuits – Voltage, Current and Power

Sub-concept#2: How a Dimmer work – Changing the voltage using semiconductors.

Sub-concept#3: The relation between the voltages applied to a lamp and the intensity of the light it released.

Concept #2: Controlling the direction of the light using mirrors

Sub-concept#1: Basic of Geometrical Optics

Sub-concept#2: Reflection and the use of concave mirrors to direct light

Sub-concept#3: Refraction and the use of lenses to direct light

Sub-concept #4: Explanation how a fixture controlled the direction of the light

Concept #3: New features to control the lighting in a theatre.

Conceptual map

Example

Rubric for the project: Controlling the light on the stage
Student Name: Juan Lopez

Topic: Controlling light

Concept	Sub-concept	Covering the concepts and sub-concepts (20% of the final grade)			Depth of concept and sub concept presented (50% of the final grade)			Score
		Not Covered	Partial covered	Covered	Below class level	At class level	Above class level	
		0	1	2	0	1	2	
Concept #1: Controlling the intensity of the light by changing the voltage applied to the lamp								
	Introduction to Electrical circuits: Voltage, Current and Power							
	How a Dimmer work – Changing the voltage using semiconductors							
	The relation between the voltage applied to an incandescent lamp and the intensity of the light it releases							
Concept #2: Controlling the direction of the light using optical devices								
	Introduction to Geometrical optics							
	Reflection and the use of concave mirrors to direct light							
	Refraction and the use of lenses to direct light							
	Explanation how a light fixture controlled the direction of the light							
Concept#3: New features to control the lighting in a theatre								
	New features to control the lighting in a theatre							

Rubric (continuation)

Technological applications of the presented concepts (20% of the final grade)

Concept Definition	Technological Application	
	Not present 0	Present 2
Concept #1: Controlling the intensity of the light by changing the voltage applied to the lamp		
Concept #2: Controlling the direction of the light using optical devices		
Concept#3: New features to control the lighting in a theatre		

Scientific communication (10% of the final grade)

Definition	Score
The project covers in an outstanding way the topic proposed to the audience. There is no need for further revisions	5
The project covers in a satisfactory way the topic proposed to the audience. There are small errors and details that required a minor review	4
The project partially conveys the topic proposed to the audience. The project includes serious errors and misconceptions that need to be addressed by implementing a major review	1
The project does not convey the topic proposed to the audience. The project includes errors and misconceptions. The project could not be presented in any way and need to be redone	0

The total score of the project will be calculated as the addition of the points obtained in the different aspects of the rubric, normalized with the maximum obtainable score and the percentage available for each category.

Media selected to the project: Documentary Film

Description of how the media selected will communicate the topic and the concepts selected for this project:

The goal of the movie is to show all the process of controlling light on the stage.

The media select for this project is a documentary film that will explain the different ways to control light in an artistic venue such as auditorium, concert hall or theatre.

At the beginning, the film will introduce using videotaped demonstrations the principles of electricity and its basic concepts: voltage, current and power, to establish that changing the power applied to a consumer, will change its product (in this case, changing the power applied to the lamp will change its intensity).

Following will be a clip explaining how a dimmer change the voltage on the lamp, and therefore it changes (controls) the intensity of the light the lamp releases. To finalize this idea a short quantitative experiment will be presented where changing the voltage changes the intensity of the light.

Now that we have the capability to change the intensity of the light, we need to be able to direct the light to the desired place. To achieve this goal, first will be introduced the basic concepts of geometrical optics using stop motion animation (what is a punctual source of light, what is a beam of light etc).

Using these concepts, an explanation of the reflection phenomenon will be introduced through a movie using small cookies as plane mirrors and ketchup and mustard as light rays, and extended to concave mirrors. In a similar way the refraction phenomenon will be explained.

Finally a short movie will be shoot in a theatre hall describing all the technological settings used to control the lighting on the stage (from the dimmer to the description of the physical components of different fixtures used to fulfill different needs for example using the fresnel to wash light on the stage, or using the ellipsoidal to concentrate light in specific areas of the stage, etc).

Definition of the projects approved by: (name of the Instructor) _____

Date:

Signature Instructor

Signature Student

Rubric Template

Rubric for the project: (title)

Student Name:

Topic:

Note: The amount of concepts and sub-concepts is up to you!!

	Sub-concept	Covering the concepts and sub-concepts (20% of the final grade)			Depth of concept and sub concept presented (50% of the final grade)			Score
		Not Covered	Partial covered	Covered	Below class level	At class level	Above class level	
		0	1	2	0	1	2	
Concept #1:								
Concept #2:								
Concept#3:								

Rubric (continuation)

Technological applications of the presented concepts (20% of the final grade)

Concept Definition	Technological Application	
	Not present 0	Present 2
Concept #1:		
Concept #2:		
Concept #3:		

Scientific communication (10% of the final grade)

Definition	Score
The project covers in an outstanding way the topic proposed to the audience. There is no need for further revisions	5
The project covers in a satisfactory way the topic proposed to the audience. There are small errors and details that required a minor review	4
The project partially conveys the topic proposed to the audience. The project includes serious errors and misconceptions that need to be addressed by implementing a major review	1
The project does not convey the topic proposed to the audience. The project includes errors and misconceptions. The project could not be presented in any way and need to be redone	0

The total score of the project will be calculated as the addition of the points obtained in the different aspects of the rubric, normalized with the maximum obtainable score and the percentage available for each category.

Definition of Project

Designing Light on stage

Student: XXXXXX

November 17, 2008

Designing Light

Concept #1: Focusing light on stage of an object and its image.

Sub-concept #1: Introducing geometrical optic concepts.

Sub-concept #2: Reflection using plane and curve mirrors.

Sub-concept #3: Refraction using lenses to focus light.

Concept #2: Focusing on how spotlight works within artistic performances

Sub-concept #1: Describing the components of a control system and how each one works.

Sub-concept #2: Explaining the relationship between voltages applied to a feature and the intensity of light produced.

Sub-concept #3: Explaining the work of a dimmer. The power electronics behind the device.

Rubric for the project: Designing Light on stage

Student Name: XXXXXXXX

Topic: Designing Light

	Sub-concept	Covering the concepts and sub-concepts (20% of the final grade)			Depth of concept and sub concept presented (50% of the final grade)			Score
		Not Covered	Partial covered	Covered	Below class level	At class level	Above class level	
		0	1	2	0	1	2	
Concept #1: Focusing light on stage of an object and its image								
	Introducing geometrical optic concepts							
	Reflection using plane and curve mirrors							
	Refraction using lenses to focus light							
Concept #2: Focusing on how spotlight works within artistic performances								
	:Describing the components of a control system and how each one works.							
	Explaining the relationship between							

	voltages applied to a feature and the intensity of light produced.							
	Explaining the work of a dimmer. The power electronics behind the device.							

Rubric (continuation)

Technological applications of the presented concepts (20% of the final grade)

Concept Definition	Technological Application	
	Not present 0	Present 2
Concept #1: Focusing light on stage of an object and its image.		
Concept #2: Focusing on how spotlight works within artistic performances		

Scientific communication (10% of the final grade)

Definition	Score
The project covers in an outstanding way the topic proposed to the audience. There is no need for further revisions	5
The project covers in a satisfactory way the topic proposed to the audience. There are small errors and details that required a minor review	4
The project partially conveys the topic proposed to the audience. The project includes serious errors and misconceptions that need to be addressed by implementing a major review	1
The project does not convey the topic proposed to the audience. The project includes errors and misconceptions. The project could not be presented in any way and need to be redone	0

Media selected to the project: Dance Performance film

Description of how the media selected will communicate the topic and the concepts selected for this project:

The goal of the film is to show the process of designing light on stage.

The media select for this project is a film that will explain different ways to design light in an artistic venue such as a theatre.

The video will go through to explain the concepts and sub concepts of designing light on stage.

A short video of a dance piece will then be shown to illustrate the technological settings used to design the lighting on the stage (from directing light, to focusing light, controlling sound and movement on stage, while showing the intensity of light control.)

Definition of the projects approved by: (name of the Instructor) _____

Date:

Signature Instructor

Signature Student