**General Education Course Inclusion Proposal**

**Quantitative Reasoning and Analysis**

*This proposal form is intended for departments proposing a course for inclusion in the Northern Michigan University General Education Program. Courses in a component satisfy both the Critical Thinking and the component learning outcomes. Departments should complete this form and submit it electronically through the General Education SHARE site.*

**Course Name and Number: PH 101 Eureka: Einstein, the Universe and Everything**

**Home Department: Physics**

**Department Chair Name and Contact Information** (phone, email): Dr. David Lucas, 227-2191, dlucas@nmu.edu

**Expected frequency of Offering of the course** (e.g. every semester, every fall): Every fall

**Official Course Status**: Has this course been approved by CUP and Senate? YES

**Overview of course** (please attach a current syllabus as well): *Please limit the overview to two pages (not including the syllabus)*

A. Overview of the course content

Ph101 is a survey course designed to introduce students to the “great ideas” of physics. The course description from the current Undergraduate Bulletin reads: “Great ideas of physics emphasizing major concepts, their development and their effect on our understanding of the natural world. Concepts include cause and effect, conservation laws, fields, relativity, cosmology, and quantum mechanics. A descriptive approach, although high school algebra is useful for some mathematical aspects.” The course is designed to show students with little technical background how the ideas are applied and interpreted, with an appropriate level of quantitative analysis.

B. Explain why this course satisfies the Component specified and significantly addresses both learning outcomes

Critical thinking – evidence: Students in the course learn the importance of “quality of evidence” by studying the development of major scientific concepts, all of which evolved as misconceptions were cleared up and poor data was improved. For example, early descriptions of motion assumed that a net force was needed to maintain constant velocity – a misconception based on reasoning from data including the effects of (eg) air resistance. They demonstrate their understanding of the issue through their responses to questions and class activities related to the development of the major concepts, and by choosing which information is relevant in more general questions.

Critical thinking – integration: The point of the “great ideas” approach is that the ideas represent parts of a whole – an integrated description of nature. Each of the major concepts developed as information from different sources was gathered and refined. For instance, the concept of energy as a conserved quantity resulted from combining the descriptions of many different physical systems which manifest energy in different forms, and which were once thought to be separate quantities. (A prime example is the conversion of heat to mechanical energy in a steam engine.) Students can demonstrate their ability to integrate information by responding to questions and activities related to the development of the concepts, and by identifying which concepts are appropriate for explaining the behavior of physical systems (for example, electrical power generation) which illustrate two or more of the basic concepts.

Critical thinking – evaluation: Following the integration of appropriate concepts, students must evaluate the outcome. What will be the behavior of the system? How will the outcome change if parameters are changed? In computational questions, this may take the form of discussing limiting cases (response to extreme parameter values) and whether they are intuitively reasonable. The same discussion can be had in descriptive questions as well.

Quantitative r/a – calculation: Although the course is aimed mainly at students with limited technical background, it affords ample opportunity for simple calculational exercises. All of the great ideas / basic concepts are expressed quantitatively. (It’s physics, after all.) An example would be finding the position of an accelerating object at different times. Another would be to find the force on a charge in an electric field.

Quantitative r/a – analysis/application: Apart from the simple mechanics of calculation, students must know which formulas they should use in a given situation (that is, use valid techniques). In many cases geometry is also important, since many basic ideas in science depend both on magnitude (number) and direction – for example, forces.

Quantitative r/a – interpretation: This material is ideal for teaching interpretation of quantitative results, since virtually all physical processes involve something changing with respect to something else – for instance, time – and so can be represented either analytically or graphically. For example, shown graphs of position versus time, students can be asked to explain whether an object is moving with constant velocity or accelerating, and in what way. For another example, concepts in cosmology, such as the deflection of starlight, can be represented graphically and interpreted by students.

C. Describe the target audience (level, student groups, etc.)

The course is appropriate for any student interested in the big ideas of science, but is aimed mainly at students but who don’t have the stronger math and science background of those in the traditional science majors. It can be taken by students at any level (freshman on up). In the past it has attracted students from many different majors.

D. Give information on other roles this course may serve (e.g. University Requirement, required for a major(s), etc.)

The course has been used to satisfy graduation requirements for some clinical sciences majors. It is sometimes taken by physics majors who want a broader or differently-integrated perspective on some of the topics covered in more advanced courses, but does not count toward the physics credits required for the major or minor.

E. Provide any other information that may be relevant to the review of the course by GEC

Syllabus Fall 2014 (Tireman) – attached  
Syllabus Fall 2010 (Jacobs) – attached

**PLAN FOR LEARNING OUTCOMES  
CRITICAL THINKING**

*Attainment of the CRITICAL THINKING Learning Outcome is required for courses in this component. There are several dimensions to this learning outcome. Please complete the following Plan for Assessment with information regarding course assignments (type, frequency, importance) that will be used by the department to assess the attainment of students in each of the dimensions of the learning outcome. Type refers to the types of assignments used for assessment such as written work, presentations, etc. Frequency refers to the number of assignments included such as a single paper or multiple papers. Importance refers to the relative emphasis or weight of the assignment to the entire course. For each dimension, please specify the expected success rate for students completing the course that meet the proficiency level and explain your reasoning. Please refer to the Critical Thinking Rubric for more information on student performance/proficiency in this area. Note that courses are expected to meaningfully address all dimensions of the learning outcome.*

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| **DIMENSION** | **WHAT IS BEING ASSESSED** | **PLAN FOR ASSESSMENT** |
| **Evidence** | Assesses quality of information that may be integrated into an argument | **Type**: Comprehensive final examination including both objective and interpretive elements. Specifically for this dimension, the proper selection of data in objective elements, and the relevant information in interpretive elements.  **Frequency**: At end of semester.  **Importance**: Exam typically 20 to 30 percent of course grade, depending on other elements of grading scheme used by instructor. This aspect typically counts for about a quarter of the credit given per item on an exam.  **Expected success rate**: 75%  Typically 70% of students in Ph101 earn C- or better. Generally speaking, in the physical sciences the process of selecting data/evidence, combining it correctly, and interpreting the result is increasingly difficult for students at each step. So the expected success rate for this item is placed somewhat higher than the overall rate.  **Type**: Take-home questions or a term paper on a topic (or topics) related to one of the “big ideas.” Specifically for this dimension, appropriate choice of background data and information.  **Frequency**: Throughout semester, or at end for term paper.  **Importance**: Typically 15 to 20 percent of course grade, depending on other elements of grading scheme used by instructor. This aspect typically counts for about a third of the credit given on a paper or particular question.  **Expected success rate**: 75%  Typically 70% of students in Ph101 earn C- or better. Generally speaking, in the physical sciences the process of selecting data/evidence, combining it correctly, and interpreting the result is increasingly difficult for students at each step. So the expected success rate for this item is placed somewhat higher than the overall rate. |
| **Integrate** | Integrates insight and or reasoning with existing understanding to reach informed conclusions and/or understanding | **Type**: Comprehensive final examination including both objective and interpretive elements. Specifically for this dimension, valid combinations of the data and information in both objective and interpretive elements.  **Frequency**: At end of semester.  **Importance**: Exam typically 20 to 30 percent of course grade, depending on other elements of grading scheme used by instructor. This aspect typically counts for about half of the credit given per item on an exam.  **Expected success rate**: 70%  Typically 70% of students in Ph101 earn C- or better. Generally speaking, in the physical sciences the process of selecting data/evidence, combining it correctly, and interpreting the result is increasingly difficult for students at each step. So the expected success rate for this item matches the overall rate.  **Type**: Take-home questions or a term paper on a topic (or topics) related to one of the “big ideas.” Specifically for this dimension, valid combination of evidence in reasoning toward conclusion.  **Frequency**: Throughout semester, or at end for term paper.  **Importance**: Typically 15 to 20 percent of course grade, depending on other elements of grading scheme used by instructor. This aspect typically counts for about a third of the credit given on a paper or particular question.  **Expected success rate**: 70%  Typically 70% of students in Ph101 earn C- or better. Generally speaking, in the physical sciences the process of selecting data/evidence, combining it correctly, and interpreting the result is increasingly difficult for students at each step. So the expected success rate for this item matches the overall rate. |
| **Evaluate** | Evaluates information, ideas, and activities according to established principles and guidelines | **Type**: Comprehensive final examination including both objective and interpretive elements. Specifically for this dimension, the ability to interpret results in particular situations, and make general predictions about behavior in related situations (e.g. by discussion of “limiting cases.”)  **Frequency**: At end of semester.  **Importance**: Exam typically 20 to 30 percent of course grade, depending on other elements of grading scheme used by instructor. This aspect typically counts for about a quarter of the credit given per item on an exam.  **Expected success rate**: 65%.  Typically 70% of students in Ph101 earn C- or better. Generally speaking, in the physical sciences the process of selecting data/evidence, combining it correctly, and interpreting the result is increasingly difficult for students at each step. So the expected success rate for this item is placed somewhat lower than the overall rate.  **Type:** Take-home questions or a term paper on a topic (or topics) related to one of the “big ideas.” Specifically for this dimension, reasonable conclusions based on interpretation/integration of concepts and data.  **Frequency:** Throughout semester, or at end for term paper.  **Importance:** Typically 15 to 20 percent of course grade, depending on other elements of grading scheme used by instructor. This aspect typically counts for about a third of the credit given on a paper.  **Expected success rate:** 65%  Typically 70% of students in Ph101 earn C- or better. Generally speaking, in the physical sciences the process of selecting data/evidence, combining it correctly, and interpreting the result is increasingly difficult for students at each step. So the expected success rate for this item is placed somewhat lower than the overall rate. |

**PLAN FOR LEARNING OUTCOMES  
QUANTITATIVE REASONING AND ANALYSIS**

*Attainment of the QUANTITATIVE REASONING AND ANALYSIS Learning Outcome is required for courses in this component. There are several dimensions to this learning outcome. Please complete the following Plan for Assessment with information regarding course assignments (type, frequency, importance) that will be used by the department to assess the attainment of students in each of the dimensions of the learning outcome. Type refers to the types of assignments used for assessment such as written work, presentations, etc. Frequency refers to the number of assignments included such as a single paper or multiple papers. Importance refers to the relative emphasis or weight of the assignment to the entire course. For each dimension, please specify the expected success rate for students completing the course that meet the proficiency level and explain your reasoning. Please refer to the Rubric for more information on student performance/proficiency in this learning outcome. Note that courses are expected to meaningfully address all dimensions of the learning outcome.*

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| **DIMENSION** | **WHAT IS BEING ASSESSED** | **PLAN FOR ASSESSMENT** |
| **Calculation** | Ability to perform mathematical/numerical operations. | **Type**: Objective (computational) elements in final examination. Specifically for this dimension, simple arithmetic correctness of work.  **Frequency**: At end of semester.  **Importance**: Exam typically 20 to 30 percent, this aspect influences all of the credit given on the computational elements.  **Expected success rate**: 80%  Typically 70% of students in Ph101 earn C- or better. Similarly to the dimensions in Critical Thinking discussed earlier, the dimensions here apply in increasing order of difficulty for most students. Therefore the expected success rate for simple calculation is placed somewhat higher than overall rate.  **Type**: Arithmetic correctness of mathematical elements cited or given in take-home questions or term paper.  **Frequency**: Throughout semester, or at end for term paper.  **Importance**: About a third of credit given for mathematical elements.  **Expected success rate**: 80%  Typically 70% of students in Ph101 earn C- or better. Similarly to the dimensions in Critical Thinking discussed earlier, the dimensions here apply in increasing order of difficulty for most students. Therefore the expected success rate for simple calculation is placed somewhat higher than overall rate. |
| **Analysis/Application** | Ability to manipulate quantitative data to produce new data.  Ability to use data to make judgments and draw conclusions. | **Type**: Objective (computational) elements in final examination. Specifically for this dimension, being able to manipulate simple mathematical expressions to (for example) isolate a quantity of interest.  **Frequency**: At end of semester.  **Importance**: Exam typically 20 to 30 percent, this aspect typically counts for half of the credit given on computational elements.  **Expected success rate**: 75%  Typically 70% of students in Ph101 earn C- or better. Given that the dimensions here apply in increasing order of difficulty for most students, the expected success rate for analysis/application matches the overall rate.  **Type**: Algebraic correctness of operations on mathematical elements cited or given in take-home questions or term paper.  **Frequency**: Throughout semester, or at end for term paper.  **Importance**: About a third of credit given for mathematical elements.  **Expected success rate**: 70%  Typically 70% of students in Ph101 earn C- or better. Given that the dimensions here apply in increasing order of difficulty for most students, the expected success rate for analysis/application matches the overall rate. |
| **Interpretation** | Ability to explain information presented in mathematical forms (e.g. equations, graphs, diagrams, tables, and words) | **Type**: Objective (computational) elements in final examination. Specifically for this dimension, a combination of explaining how results will change if the given data are changed, limiting-case analysis, and graphical interpretation. (For example, and student might be asked to compute the acceleration of an object subjected to a given force, and then explain how the acceleration will change if the force or mass are varied, or to show position versus time graphically.)  **Frequency**: At end of semester.  **Importance**: Exam typically 20 to 30 percent, this aspect typically counts for a quarter of the credit given on computational elements.  **Expected success rate**: 65%  Typically 70% of students in Ph101 earn C- or better. Given that the dimensions here apply in increasing order of difficulty for most students, the expected success rate for interpretation is placed somewhat lower than the overall rate.  **Type**: Interpretation of mathematical elements cited or given in take-home questions or term paper. In particular, being able to explain how results will vary with changes in data, or graphically or in written form.  **Frequency**: Throughout semester, or at end for term paper.  **Importance**: About a third of credit given for mathematical elements.  **Expected success rate**: 65%  Typically 70% of students in Ph101 earn C- or better. Given that the dimensions here apply in increasing order of difficulty for most students, the expected success rate for interpretation is placed somewhat lower than the overall rate. |