**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: Stellar/Galactic Astronomy and Cosmology / AS 104**

**Home Department: Physics Department**

**Department Chair Name and Contact Information** (phone, email): Dr. David Lucas, 2517 West Science 227-2191

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

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

*Courses that have not yet been approved by CUP must be submitted to CUP prior to review by GEC. Note that GEC is able to review courses that are in the process of approval; however, inclusion in the General Education Program is dependent upon Senate and Academic Affairs approval of the course into the overall curriculum.*

**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

AS 104 is a survey course designed to introduce students to the concepts of astronomy outside of our solar system. The course studies the properties of our star, the Sun, as we currently understand them. Combining this information with information we have on other stars, the life cycle of stars is examined. The results of the end of star lives are black holes, white dwarfs, neutron stars, and pulsars which are each considered. Collections of stars form galaxies which are studied. The patterns of galaxies allow us to consider the entire universe. Finally theories of how the universe is formed and will evolve and potential futures of the universe are explored.

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

**Critical Thinking Outcome:**

**Evidence:**

In AS 104 students assess the quality of information used in several ways. In laboratory exercises students have to examine a variety of experimental quantities and demonstrate that they understand which physical quantities are needed for the experiment and which are not. For example in one lab students are provided a number of photographs taken of the Sun by various solar orbiting satellites. They examine sunspot groupings in these photos and make decisions about sunspots to use in order to calculate the rotation rate of the sun. In another lab, students make measurements on several gaseous elements and then identify which elements exist in the fluorescent lights in the room.

Exams and quizzes contain questions that require students to determine which pieces of information provided should be used to solve the question or to explain the question asked. For example a student may be provided with a star’s mass, equatorial diameter, distance from a planet or comet, and other quantities. The student must choose which of these are needed to determine how likely the star will form a black hole, or what the rotation rate of a

All students are required to submit an Astronomy Picture of the Day (APOD) form at each lab. This requires students to read and view the APOD website maintained by NASA and to reflect on and comment on a picture each week. Often students will comment on the information provided by the astronomer.

**Integrate:**

Exam and quiz questions require students to take basic information and use it to answer problems and questions that they have not been exposed to previously. For example students solve for the brightness of a star and then use that to determine distance from that star to Earth.

Students in lab exercises often have to combine more than one measurement to completely solve or answer a question or task. For example plot out light curves for Cepheid variable stars. They use the properties of the light curves to then determine distances from the Cepheid variable stars using a second graph based on absolute brightness.

**Evaluate:**

Laboratory exercises provide opportunities for students to make calculations and actual measurements. These two sets of data can then be compared to see how valid either the calculations or the measurements are. Students often must consider how earlier measurements have affected results of experiments based on those measurements. For example students make parallax measurements using optical lines of sights. From these measurements and some geometry linear distances are determined. Students then use actual tape measures and meters sticks and measure the distance in the hallway. They can compare how close the two sets of measurements are.

**Quantitative Reasoning and Analysis Outcome:**

**Calculation:**

Exam and quiz questions will have students making calculations to solve problems and answer questions. Students might be provided an object’s mass and asked what force would be required to accelerate the object on different planets and moons. Students may be given the diameter and mass of a black hole and from that they can calculate the Schwarzschild radius which is the distance from the black hole from which not even light can escape from the black hole.

All of the laboratory exercises require calculations to complete the work of the lab. For example students will calculate the Hubble constant of the universe from photographs and Doppler shift measurements.

**Analysis/Application:**

Laboratory exercises require students to make plots of data. From these plots determine slopes of lines or y-intercepts. Finally use those results to determine another quantity. For example, students plot the rotational speed of various parts of the Andromeda galaxy. They then adjust the plot to remove the Doppler motion of the galaxy. Finally they are able to calculate the mass of the galaxy by using the pure rotational motion.

Quiz and exam questions require students to consider the results of calculations to answer further questions. For example students can determine the vibration of a pulsar’s flashing from the neutron’s star original angular momentum which must be conserved even though the star loses most of its diameter as the mass condenses down from star sized to approximately city sized. Students can then look at the rotation rate of the pulsar and determine how long it will take to radiate much of the energy away.

**Interpretation:**

Quiz and exam questions involve determining what a plot tells us about a physical quantity. For example after showing them a Hertzsprung-Russell diagram of a galactic cluster they can determine the relative age of the cluster.

Laboratory exercises provide opportunities for students examine plots of star positions being moved during a solar eclipse. After making calculations of the gravitational forces resulting in these movements on the photo, students can decide if principles of general relativity or special relativity is responsible.

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

The primary audience for AS 104 has been and we expect it to be students who wish to satisfy the Laboratory graduation requirement by taking a science course which slightly less mathematical rigor or scientific depth than the traditional introductory lab courses in physics, chemistry, biology, etc. AS 104 has also been used as a required course for some education majors and some earth science majors. There is also a small but consistent core of students who just are curious about astronomy and want to learn more about it.

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

As mentioned above this course is required for some education majors and some earth science majors. It is also used often for the university lab graduation requirement. Physics majors may take the course but it will not satisfy 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

N/A.

**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** | **DIMENSION GUIDANCE** | **PLAN FOR ASSESSMENT** |
| **Evidence** | Assesses quality of information that may be integrated into an argument | **Type:** Quiz and Exam questions**Relation to Dimension:** Students decide what information to use to solve problems and answer questions.**Frequency:** Quizzes Weekly, Exams 2-3 in semester, 1 Final Exam**Importance:** Quiz and Exams are 55% of overall grade**Success Rate:** Approximately 72% of students get a C- or better in AS 104, to be consistent with AS 103 we will anticipate a success rate is 65%.**Type:** Laboratory Exercises**Relation to Dimension:** Students choose how to make measurements and to select which measurements to make. **Frequency:** Weekly**Importance:** Labs are 20% of overall grade**Success Rate:** Approximately 72% of students get a C- or better in AS 104, to be consistent with AS 103 we will anticipate a success rate is 65%.**Type:** Astronomy Picture of the Day (APOD)**Relation to Dimension:** Students comment on the astronomer’s comments about where the information comes from and the value of it. **Frequency:** Weekly**Importance:** APODs are 20% of Lab Grade, so 4% of overall grade**Success Rate:** Approximately 72% of students get a C- or better in AS 104, to be consistent with AS 103 we will anticipate a success rate is 65%. |
| **Integrate** | Integrates insight and or reasoning with previous understanding to reach informed conclusions and/or understanding | **Type:** Quiz and Exam questions**Relation to Dimension:** Students must combine the results of parts of questions and problems to complete solutions and answers.**Frequency:** Quizzes Weekly, Exams 2-3 in semester, 1 Final Exam**Importance:** Quiz and Exams are 55% of overall grade**Success Rate:** Approximately 72% of students get a C- or better in AS 104, to be consistent with AS 103 we will anticipate a success rate is 65%.**Type:** Laboratory Exercises**Relation to Dimension:** Students have to make measurements to use in future/additional measurements.**Frequency:** Weekly**Importance:** Labs are 20% of overall grade**Success Rate:** Approximately 72% of students get a C- or better in AS 104, to be consistent with AS 103 we will anticipate a success rate is 65%. |
| **Evaluate** | Evaluates information, ideas, and activities according to established principles and guidelines | **Type:** Quiz and Exam questions**Relation to Dimension:** Students answer questions about the results they obtained in other parts of problems/questions.**Frequency:** Quizzes Weekly, Exams 2-3 in semester, 1 Final Exam**Importance:** Quiz and Exams are 55% of overall grade**Success Rate:** Approximately 72% of students get a C- or better in AS 104, to be consistent with AS 103 we will anticipate a success rate is 65%.**Type:** Laboratory Exercises**Relation to Dimension:** Students make judgments on the quality of their work by comparison with accepted results.**Frequency:** Weekly**Importance:** Labs are 20% of overall grade**Success Rate:** Approximately 72% of students get a C- or better in AS 104, to be consistent with AS 103 we will anticipate a success rate is 65%. |

**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** | **DIMENSION GUIDANCE** | **PLAN FOR ASSESSMENT** |
| **Calculation** | Ability to perform mathematical/numerical operations. | **Type:** Quiz and Exam questions**Relation to Dimension:** Students solve mathematical problems. **Frequency:** Quizzes Weekly, Exams 2-3 in semester, 1 Final Exam**Importance:** Quiz and Exams are 55% of overall grade**Success Rate:** Approximately 72% of students get a C- or better in AS 104, to be consistent with AS 103 we will anticipate a success rate is 65%.**Type:** Laboratory Exercises**Relation to Dimension:** Students perform calculations with experimentally obtained values to determine desired quantities which the experiment was to provide.**Frequency:** Weekly**Importance:** Labs are 20% of overall grade**Success Rate:** Approximately 72% of students get a C- or better in AS 104, to be consistent with AS 103 we will anticipate a success rate is 65%. |
| **Analysis/Application** | Ability to manipulate quantitative data to produce new data.Ability to use data to make judgments and draw conclusions. | **Type:** Quiz and Exam questions**Relation to Dimension:** Students combine work and results from other parts of questions or problems to find solutions to current questions or problems.**Frequency:** Quizzes Weekly, Exams 2-3 in semester, 1 Final Exam**Importance:** Quiz and Exams are 55% of overall grade**Success Rate:** Approximately 72% of students get a C- or better in AS 104, to be consistent with AS 103 we will anticipate a success rate is 65%.**Type:** Laboratory Exercises**Relation to Dimension:** Students use results of one set of measurements to create another set of measurements.**Frequency:** Weekly**Importance:** Labs are 20% of overall grade**Success Rate:** Approximately 72% of students get a C- or better in AS 104, to be consistent with AS 103 we will anticipate a success rate is 65%. |
| **Interpretation** | Ability to explain information presented in mathematical forms (e.g. equations, graphs, diagrams, tables, and words) | **Type:** Quiz and Exam questions**Relation to Dimension:** Students consider how their answers allow them to expand on and to finalize the answer to questions or problems.**Frequency:** Quizzes Weekly, Exams 2-3 in semester, 1 Final Exam**Importance:** Quiz and Exams are 55% of overall grade**Success Rate:** Approximately 72% of students get a C- or better in AS 104, to be consistent with AS 103 we will anticipate a success rate is 65%.**Type:** Laboratory Exercises**Relation to Dimension:** Students answer questions about graphs and mathematical models they have created in the lab exercise. **Frequency:** Weekly**Importance:** Labs are 20% of overall grade**Success Rate:** Approximately 72% of students get a C- or better in AS 104, to be consistent with AS 103 we will anticipate a success rate is 65%. |