Term Information

Effective Term	Autumn 2024

General Information

Course Bulletin Listing/Subject Area	Physics
Fiscal Unit/Academic Org	Physics - D0684
College/Academic Group	Arts and Sciences
Level/Career	Undergraduate
Course Number/Catalog	2100
Course Title	Physics and Technology for Future Presidents
Transcript Abbreviation	Phys Tech Fut Pres
Course Description	Using physics concepts and scaling laws, students will explore problems of societal importance, including energy security and sustainability, global warming, space technologies, quantum physics, and machine learning. This will establish a knowledge base for future leaders in government, companies, and organizations who must adapt to an ever-changing world where technologies play a critical role.
Semester Credit Hours/Units	Fixed: 4

Offering Information

Length Of Course	14 Week
Flexibly Scheduled Course	Never
Does any section of this course have a distance education component?	No
Grading Basis	Letter Grade
Repeatable	No
Course Components	Lecture, Recitation
Grade Roster Component	Lecture
Credit Available by Exam	No
Admission Condition Course	No
Off Campus	Never
Campus of Offering	Columbus, Lima, Mansfield, Marion, Newark, Wooster

Prerequisites and Exclusions

Prerequisites/Corequisites	Math 1075 or higher; or instructor permission
Exclusions	
Electronically Enforced	Yes

Cross-Listings

Cross-Listings

Subject/CIP Code

Subject/CIP Code	40.0801
Subsidy Level	Baccalaureate Course
Intended Rank	Freshman, Sophomore, Junior, Senior

Requirement/Elective Designation

Number, Nature, Mind

Course Details

Course goals or learning objectives/outcomes

- Students will engage in critical and logical thinking about physics and technology by using the mathematical scaling laws that underly the physical theories.
- Students will engage in an advanced, in-depth, scholarly exploration of the ideas and concepts learned in this course.
- Students will identify, describe, and synthesize approaches or experiences by applying their knowledge to problems they have not seen previously.
- Students will demonstrate a developing sense of self as a learner through reflection, self-assessment and creative work, building on prior experiences to respond to new and challenging contexts throughout the course.
- Students will analyze and describe how mathematics functions as an idealized system that enables logical proof and/or as a tool for describing and understanding the natural world using scaling laws.

Content Topic List

- 1. Energy and power and the physics of explosions
  2. Atoms and heat
  3. Gravity, force, and space
  4. Nuclei and radioactivity
  5. Chain reactions, nuclear reactors, and atomic bombs
  6. Electricity and magnetism
- 7. Review, midterm exam
  8. Light
  9. Invisible light
  10. Climate change
  11. Quantum physics
  12. The Universe
- 13. Quantum computing
  14. Machine learning

Sought Concurrence

No

Attachments

- Physics_2100_GEThemeLearningGoals.pdf

  (Other Supporting Documentation. Owner: Thaler,Lindsey Nicole)
- Physics_2100_Syllabus_Feb2024.pdf

  (Syllabus. Owner: Thaler,Lindsey Nicole)
- PhysicsFuturePresidents-Research and Creative Inquiry final version 11-17-23.docx: Research and Creative Inquiry Form

  (Other Supporting Documentation. Owner: Thaler,Lindsey Nicole)

Comments

- Both an updated syllabus and the Research and Creative Inquiry Form are attached. Thank you. *(by Thaler,Lindsey Nicole on 02/21/2024 07:46 AM)*
- - Please upload the filled out Research and Creative Inquiry Form. I will send it by email. Thanks. *(by Vankeerbergen,Bernadette Chantal on 12/08/2023 12:59 PM)*

Workflow Information

Status	User(s)	Date/Time	Step
Submitted	Thaler,Lindsey Nicole	11/22/2023 12:01 PM	Submitted for Approval
Approved	Humanic,Thomas John	11/22/2023 01:47 PM	Unit Approval
Revision Requested	Vankeerbergen,Bernadette Chantal	11/27/2023 12:59 PM	College Approval
Submitted	Thaler,Lindsey Nicole	12/08/2023 11:52 AM	Submitted for Approval
Approved	Humanic,Thomas John	12/08/2023 12:35 PM	Unit Approval
Revision Requested	Vankeerbergen,Bernadette Chantal	12/08/2023 12:59 PM	College Approval
Submitted	Thaler,Lindsey Nicole	02/21/2024 07:46 AM	Submitted for Approval
Approved	Humanic,Thomas John	02/21/2024 08:48 AM	Unit Approval
Approved	Vankeerbergen,Bernadette Chantal	02/22/2024 01:53 PM	College Approval
Pending Approval	Jenkins,Mary Ellen Bigler Hanlin,Deborah Kay Hilty,Michael Neff,Jennifer Vankeerbergen,Bernadette Chantal Steele,Rachel Lea	02/22/2024 01:53 PM	ASCCAO Approval

Syllabus:
Physics 2100
Physics and Technology for Future Presidents

Autumn 2024

Course Information

- **Instructor:** Prof. Dan Gauthier (gauthier.51@osu.edu)
- **Course times:** To be decided.
- **Credit hours:** 4
- **Mode of delivery:** In person; two 80-minute lectures (either TuTh or WF) and one 80-minute recitation per week (M or Tu)
- **This course satisfies a GEN Theme: Number, Nature, Mind**

Course Prerequisites

Math 1075 or above; or instructor permission

Course Description

Using physics concepts and scaling laws, students will explore problems of societal importance, including energy security and sustainability, global warming, space technologies, quantum physics, and machine learning. This will establish a knowledge base for future leaders in government, companies, and organizations who must adapt to an ever-changing world where technologies play a critical role.

Required Textbooks and Materials

Physics and technology for future presidents: An introduction to the essential physics world leader needs to know, R. A. Muller (Princeton University Press, Princeton, 2010)

Supplementary course materials on Canvas Carmen (carmen.osu.edu)

Course Goal

Apply mathematical scaling laws of basic physical theories to problems of societal importance to gain an appreciation of the synergy between mathematics and physics and perspectives of how science and technology inform leadership decision making.

Learning Outcomes

- Students will engage in critical and logical thinking about physics and technology by using the mathematical scaling laws that underly the physical theories.

- Students will engage in an advanced, in-depth, scholarly exploration of the ideas and concepts learned in this course.
- Students will identify, describe, and synthesize approaches or experiences by applying their knowledge to problems they have not seen previously.
- Students will demonstrate a developing sense of self as a learner through reflection, self-assessment and creative work, building on prior experiences to respond to new and challenging contexts throughout the course.
- Students will analyze and describe how mathematics functions as an idealized system that enables logical proof and/or as a tool for describing and understanding the natural world using scaling laws.

The course will be taught using a pedagogical approach known at Team Based Learning [https://www.teambasedlearning.org/], an evidence-based learning approach that is known to promote student success even in a large-class setting. It uses a sequence of learning modules that have a common framework: preparation, in-class readiness assurance assessment, mini-lectures, and application-focused exercises. Here, the exercises will be done in groups during lecture using an electronic polling system such as TopHat Student Response System, and in groups during the recitation section guided by the teaching assistant.

OSU Physics Professor Gauthier has successfully used Team Based Learning in upper-level interdisciplinary undergraduate/graduate level courses and large-scale introductory physics courses while at Duke University, and in upper-level interdisciplinary 6800-level courses at Ohio State University. He has given conference presentations on the evidence demonstrating improved student success.

Physics 2100 is a GEN Theme: Number, Nature, Mind

Goals of the GEN Theme: Number, Nature, Mind:

1. Successful students will analyze the ideas embodied within “Number, Nature, Mind” at a more advanced and in-depth level than in the Foundations component.

2. Successful students will integrate approaches to understanding the ideas embodied within “Number, Nature, Mind” by making connections to out-of-classroom experiences with academic knowledge or across disciplines and/or to work they have done in previous classes and that they anticipate doing in future.

3. Successful students will experience and examine mathematics as an abstract formal system accessible to mental manipulation and/or mathematics as a tool for describing and understanding the natural world.

Expected Learning Outcomes of the GEN Theme: Number, Nature, Mind:

Successful students are able to:

1.1 Engage in critical and logical thinking about the ideas embodied within “Number, Nature, Mind”.

1.2 Engage in an advanced, in-depth, scholarly exploration of the ideas embodied by “Number, Nature, Mind”.

2.1 Identify, describe, and synthesize approaches or experiences as they apply to “Number, Nature, Mind”.

2.2 Demonstrate a developing sense of self as a learner through reflection, self-assessment and creative work, building on prior experiences to respond to new and challenging contexts.

3.1 Analyze and describe how mathematics functions as an idealized system that enables logical proof and/or as a tool for describing and understanding the natural world.

How Physics 2100 meets the above goals and expected learning outcomes:

The relation between mathematics and physics is profound, leading to quantitative predictions of the world around us. While it can take years to master these mathematical theories, much headway can be made by learning basic physics concepts and how the underlying theory depends on physical quantities – known as scaling laws. Using physics concepts and scaling laws, students in this course will explore a variety of problems of societal importance, including energy security and sustainability, global warming, information, imaging, and space technologies, radiation physics, quantum physics, machine learning, and exploring the universe. This approach will establish an important knowledge base for future leaders of the United States government, companies, boards, or non-government organizations, who must adapt to an ever-changing world where technologies play a critical role.

ELO 1.1 Students will engage in critical and logical thinking about physics and technology by using the mathematical scaling laws that underly the physical theories. For each major course topic, students will have multiple engagements with the scaling laws:

1) They will learn the basic concepts and scaling laws through pre-lecture readings from the text and other on-line resources (the first component of a learning module);

2) At the beginning of each class, they will take a brief quiz – known as a "readiness assurance assessment," to verify that they have prepared for the lecture (counts towards 15% of the course grade, the second component of a learning module);

3) During lecture, there will be multiple pauses for them to consider a problem in small teams and answer "clicker questions" using, for example, the TopHat Student Response System, where the lecture content will be adjusted based on the outcome of the clicker question. This is known as Just-In-Time teaching, a student-centered pedagogy that fits well in the framework of Team Based Learning. These in-class questions do not count toward course grade and are part of the third component of a learning module;

4) During the first 50 minutes (out of 80) of weekly recitation, students will be guided by a teaching assistant through relevant estimation problems using the appropriate scaling laws, completed in a small team setting (part of the third component of a learning module, 20% of course grade);

5) A semester-long research project with intermediate assignments and a final 5-page paper (25% of the course grade). Students will select a research topic where they will:

a) Identify the key physics/technology issue
b) Identify and apply appropriate scaling laws
c) Demonstrate critical analysis of the problem
d) Discuss implications for future leaders

Topics for the project will be suggested on the Carmen course site with initial sources provided, or students can select their own topic and initial sources with approval by the instructor/teaching assistant at one of the intermediate “touch points” of the project described next.

The project will have major “touch points” to verify that they are keeping on track with the project and undertaking a substantial project. The touch points will not be graded, but students must complete them on time if they want to receive the highest mark for their paper.

Students will also be given time in the recitation section for their research project. During some recitation sections, the teaching assistant will discuss different aspects of the paper, such as where to find sources, academic writing format, citing sources, and the technology for writing the paper. On other recitation days, students will be allocated time to undertake some of their research, where they can ask their team members and recitation instructor for advice.

The touch points include These will not be graded but feedback will be provided to each student):

End of week 3: A one-paragraph description of their research topic proposal summarizing their topic a minimum of three initial sources.

End of week 5: A one-paragraph description of the primary scaling laws that will be needed to perform their analysis.

End of week 8: A one-paragraph summary of where they stand on their analysis.

End of week 10: A one-paragraph summary of the implications of their findings for future leader.

End of week 13: Final 5-page paper submitted.

During the final 30 minutes of each recitation section, students will undertake part of the research where they can ask their team members and teaching assistant for advice or clarification.

6) They will apply scaling laws to a few problems during a mid-term and final exam (20% of the course grade).

ELO 1.2 Students will engage in an advanced, in-depth, scholarly exploration of the ideas and concepts learned in this course using the same structure described in 1.1 above. The engagements and assessments are “advanced” because the students will be asked to apply their gained knowledge to problems they have not seen before, demonstrating knowledge generalization. Point 5) above, where students will identify a media piece of interest to them is a key skill they will take away from the course. Here, they will assess the piece to help understand the prevalence of science and technology embellishment or inaccuracy that is becoming more

prevalent. Assessment of knowledge attainment will be through a progressive, scaffolded approach. They will be assessed with low-stakes quizzes in class and problem solving in recitation so they will be prepared to demonstrate advanced problem solving and analysis during the exams.

ELO 1.2 Students will engage in an advanced, in-depth, scholarly exploration of the ideas and concepts learned in this course using the same structure described in 1.1 above. The engagements and assessments are "advanced" because the students will be asked to apply their gained knowledge to problems they have not seen before, demonstrating knowledge generalization. Point 5) above, where students will undertake a semester-long research project where they undertake an in-depth analysis of a topic related to the course, is a key skill they will take away from the course. Here, they will research a topic and write a 5-page paper. One part of the project is to understand the prevalence of science and technology embellishment or inaccuracy, a growing trend in the popular media. Assessment of knowledge attainment will be through a progressive, scaffolded approach. They will be assessed with low-stakes quizzes in class and problem solving in recitation so they will be prepared to demonstrate advanced problem solving and analysis during the exams and their research project.

ELO 2.1 Students will identify, describe, and synthesize approaches or experiences by applying their knowledge to problems they have not seen previously. Especially important in this regard will be using their knowledge to assess claims in the sources identified in their research project. They will be encouraged to identify multiple sources for their project, including from course documents and library study, as well as popular media stories/videos. They will be expected to assess both the strengths and weakness of the work using the mathematical techniques develop in class and to give opposing viewpoints in their 5-page research paper.

ELO 2.2 Students will demonstrate a developing sense of self as a learner through reflection, self-assessment and creative work, building on prior experiences to respond to new and challenging contexts throughout the course. For example, they will respond to questions posed during class by working in small teams and then entering their answer through a polling system. The overall class will discuss the results of the poll and reflect on why other teams arrived at different answers. In the recitations, they will work in teams to analyze different problems related to the current course topic, but problems they have not seen before. They will be guided to reflect on their approach to solving these problems to arrive at a systematic method for approaching unknown problems. As an individual, they will undertake a semester-long research project on a topic of their choosing but directly related to the course. They will undertake a research project that synthesizes course and library readings and online media stories or video related to science/technology/policy. They will perform a critical assessment of the topic. They will then reflect on how they would integrate this knowledge to make decisions in a possible future leadership role. The results of their research project will be summarized in a 5-page paper due near the end of the semester.

ELO 3.1 Students will analyze and describe how mathematics functions as an idealized system that enables logical proof and/or as a tool for describing and understanding the natural world using scaling laws. Scaling laws are a powerful approach for learning the underlying physics concepts and applying them to various problems. Such scaling laws are often not taught or emphasized in upper-level physics courses even though these courses usually delve into the full mathematical theories. This course will up-end the standard pedagogical approach in the physics discipline by starting with the concepts and scaling laws and showing how this approach can give key insights. In fact, most science and technology experts use the approach taken in this course to do a quick assessment of a problem or claim, yet it is usually learned only through practical experience. Throughout the semester, students will learn how to critique scientific claims using scaling law. For example, one recent claim is that a solar farm with an area of 22 square miles would be enough to satisfy the power demands of the United States. This claim can be assessed knowing the solar radiation flux at the surface of the Earth and how the power generated by a solar panel scales with the area of the panel. To take the problem further and give the problem further richness, students will predict the loss of power over transmission lines by knowing the scaling of this loss with distance and the distance scale of the United States.

How This Course Works

Mode of delivery:
This course expected to be delivered in person. If University policy requires a change in the delivery method due to COVID restrictions, then arrangements will be made to deliver instruction via Zoom or equivalent. If you have University sponsored events that might cause you to miss a one or more classes, discuss it with me *as soon as possible.*

Credit hours and work expectations:
This is a 4 credit-hour course that includes lecture, laboratory, and recitation components. According to Ohio State bylaws on instruction (go.osu.edu/credithours), students should expect 4 hours of in-class work per week (this includes 160 minutes of lecture and 80 minutes of recitation) in addition to 8 hours outside of class (reading and assignment preparation, for example) to receive a grade of [C] average.

Attendance Policy:
Class attendance policy: Students can only complete the readiness assurance during the class and only complete the activities during the discussion/recitation section. Students are allowed to miss two readiness assurance and two activities during the semester without consequence. Beyond this, students will receive a zero score for the assessment.

Disciplinary expectations and norms:
The physics discipline is a quantitative science that uses mathematics as the language for underlying theories and analysis of problems. For most research projects in the discipline, it is expected that students will use mathematical analysis of the theories to support the claims of the study. What is challenging for students is that there are apparently many theories, and it is challenging for them to take the right approach.

Rather than expecting that students can derive the mathematical theories, they will be taught so-called scaling laws, which specifies how a physical prediction scales with variation in an underlying quantity on which the theory depends. For example, for a solar energy panel, the power produced by the panel scales with the solar constant, the atmospheric transmission, the area of the panel (assuming it is oriented toward the Sun), and the device efficiency. Using algebra only, students can determine the area of a solar array needed to supply the citizens of the United States with power if they were to research the current daily energy consumption and knowing the number of seconds in a day.

Another research expectation is that students can interpret the result of their analysis in the context of their research claims. This goes beyond pure mathematics and gives physical insight to the analysis.

For all research problems, students will be expected to identify the appropriate scaling laws for their topic and use them to make quantitative predictions related to their topic. Furthermore, they will be required to interpret their results and use it for a critical analysis of their research topic. This is described in the Research Project Description of this syllabus.

Ethical implications for research and creative inquiry:
In this course, students will be confronted with problems that do not have a known or accepted answer. As a future leader, the science underlying a topic is only one point to consider. There are social and political points that must be considered before a leader can decide on a course of action. These ethical considerations will be discussed in every lecture and historical examples will be discussed in the context of the environment in which a decision was made in the past and how changes in the world might give rise to a different decision. The course

will not push one outcome over another; the goal is to make sure the science analysis is done correctly and present all sides of an issue beyond the science. It is up to the students to arrive at and defend a particular decision/course of action.

Course Materials, Fees, and Technologies

Required Textbook and Materials

- *Physics and technology for future presidents: An introduction to the essential physics world leader needs to know*, R. A. Muller (Princeton University Press, Princeton, 2010)
- Supplementary course materials on Canvas Carmen (carmen.osu.edu)

Carmen Canvas Access

You will need to use BuckeyePass (buckeyepass.osu.edu) multi-factor authentication to access your courses in Carmen. To ensure that you are able to connect to Carmen at all times, it is recommended that you do each of the following:

- Register multiple devices in case something happens to your primary device. Visit the BuckeyePass - Adding a Device (go.osu.edu/add-device) help article for step-by-step instructions.
- Request passcodes to keep as a backup authentication option. When you see the Duo login screen on your computer, click **Enter a Passcode** and then click the **Text me new codes** button that appears. This will text you ten passcodes good for 365 days that can each be used once.
- Install the Duo Mobile application (go.osu.edu/install-duo) on all of your registered devices for the ability to generate one-time codes in the event that you lose cell, data, or Wi-Fi service.

If none of these options will meet the needs of your situation, you can contact the IT Service Desk at 614-688-4357 (HELP) and IT support staff will work out a solution with you.

Technology Skills Needed for This Course

- Basic computer and web-browsing skills
- Navigating CarmenCanvas (go.osu.edu/canvasstudent)

Technology Support

For help with your password, university email, CarmenCanvas, or any other technology issues, questions or requests, contact the IT Service Desk, which offers 24-hour support, seven days a week.

- **Self Service and Chat**: go.osu.edu/it
- **Phone:** 614-688-4357 (HELP)
- **Email:** servicedesk@osu.edu

Grading and Assignments

How Your Grade is Calculated

Assignment Category	Points
Weekly in-class readiness assurance	15%
Weekly team-based application activities	15%
Mid-term exam	20%
Final exam	20%
Semester long research project	25%
Posting research project on course blog/website	5%

Students can only complete the readiness assurance during the class and only complete the activities during the discussion/recitation section. Students are allowed to miss two readiness assurance and two activities during the semester without consequence. Beyond this, students will receive a zero score for the assessment.

Descriptions of Course Assignments

(15%) Weekly in-class readiness assurance based on the reading
Weekly in-class readiness assurance based on the reading given in lecture on the first class of a learning module (one learning module per week) Format and grading: Approximately 5 TopHat multiple-choice questions each, one point for each question, a total of 5 points for each readiness assurance assessment. Students are expected to read approximately 15 pages outside of class in preparation for each readiness assurance assessment.

(15%) Weekly application of concepts to relevant problems completed during discussion/recitation section within collaborative groups (during class)
The core part of the course is for students to learn about physical scaling laws, how to use them to make quantitative predictions, and to interpret the results. Students will respond to questions posed during class by working in small teams and then entering their answer through a polling system. The overall class will discuss the results of the poll and reflect on why other teams arrived at different answers. In the recitations, Students will work in teams to analyze different problems related to the current course topic, but problems they have not seen before. Students will be guided to reflect on their approach to solving these problems to arrive at a systematic method for approaching unknown problems.

There will be approximately three problems per recitation section. Teams will use either TopHat or IF-AT scratch-off cards (https://learntbl.ca/if-at-immediate-feedback-assessment-technique/) provided by the course. For each problem, students will answer questions related to (equally weighted):

Identifying the key physics/technology issue
Identifying the appropriate scaling laws
Use the appropriate scaling laws to make a prediction
Identify implications for future leaders

Students are allowed to make multiple selections until they obtain the correct answer, where the highest credit will be given to correct answers on the first attempt.

(25%) Semester-long individual research project culminating in a 5-page paper.
A semester-long research project with intermediate touchpoints and a final 5-page paper (single spaced, 11-point font, 1” margins, citations and figures do not count against the 5-page limit, 25% of the course grade). It is anticipated that students will spend 5 hours per week on average throughout the semester. Some of this effort will be undertaken in the recitation sections (30 minutes per recitation section will be set aside for this purpose), but most of the effort will be out of the classroom. Students will select a research topic where they will:

a) Identify the key physics/technology issue

Students will select a topic to research during the semester of their choosing with approval by the instructor. Students will be encouraged to select a topic of current interest, although topics of historical significance that are viewed as particularly important for its national or international implications are welcome. A curated list of suggested topics will be provided on the Carmen Canvas course site and can be selected without obtaining instructor permission. For topics outside of these resources, the student needs to present their idea orally to one of the course instructors. If approved, the topic will then be added to the resource page for future use.

Once the topic is selected, students will identify a minimum of three additional initial sources that they will use for their project. To obtain the highest grade, these sources should be from scholarly works such as books or journal articles. Time will be set aside during lecture and recitation to discuss where to find sources, academic writing format, citing sources, and the technology for writing assignments. It is anticipated that students will identify additional sources during the project.

By the end of week 3, students will turn in a one-paragraph description of their research topic proposal summarizing their topic citations to their three initial sources.

For the final paper, this project topic will form the Introduction with an anticipated length of 1 page and include an original “storyboard” illustration that summarizes the project.

b) Identify and apply appropriate scaling laws

This part of the project connects the topic to the “Number, Nature, Mind” theme by identifying how mathematics and physical scaling laws can be used to understand our world. Student will identify the appropriate scaling laws needed to analyze their problem.

By the end of week 5, students will submit a one-paragraph description of the primary scaling laws that will be needed to perform their analysis.

For the final paper, this project topic will form the Scaling Laws section. Here, they will state the scaling laws, explain why they are appropriate for the topic, and give some context or history of how the scaling laws were deduced. The anticipated length for this section is 1 page.

c) Demonstrate critical analysis of the problem

Here, students will undertake the core analysis for the project. They will use the scaling laws to make a critical assessment of the claims made in their original topic article and demonstrate how the analysis can be extended to different situations (generalized). Students need to clearly state assumptions and limitations of their analysis.

By the end of week 8, students will submit a one-paragraph summary of where they stand on their analysis.

For the final paper, this project topic will form the Analysis section. The anticipated length for this section is two pages and will likely include 1-2 figures/illustrations.

d) Discuss implications for future leaders

To wrap up the project, the students will reflect on their research and analysis and discuss implications for future leaders. They will place the topic in the context of similar topics facing past leaders and explain why the topic may appear as a decision point for future leaders. Finally, based on their analysis, they will describe how they would make a decision on the topic if they were a future leader.

By the end of week 10, students will submit one-paragraph summary of the implications of their findings for future leader.

For the final paper, this project topic will form the Implications for Future Leaders section. The anticipated length for this section is one page.

The final paper will be submitted by the end of week 12.

Grading for the 5-page research paper will be on a 12-point scale, with a scale of 0-3 points for each item a)-d) in the table below will be graded on a 0-3 point scale using the following rubric.

a) Identify the key physics/technology issue
b) Identify and apply appropriate scaling laws
c) Demonstrate critical analysis of the problem
d) Discuss implications for future leaders

Rubric:

Points	Requirements
0	Did not turn in assignment or address any item a)-d).

1	Lacking in one or more of the metrics listed for 2 points or substantial deficiencies in any one metric
2	Demonstrates ability to address the item in a)-d) Minor deficiencies are allowed for each item.
3	Especially strong statements in items a)-d). Also, no spelling or grammar errors, and every intermediate "touch point" and the final-5-page paper turned in by the posted deadline.

<u>(20%) One in-class midterm exam</u>
The mid-term exam will consist of 20 multiple choice questions and an essay. The questions are like the readiness assurance assessment questions and recitation problem questions. TopHat or similar technology will be used to administer this part of the exam. The essay will be like the bi-weekly essays based on a prompt given in the exam, where students will select one of three prompts to work. Grading will be identical to the bi-weekly essays.

<u>(20%) Final</u>
The final exam will be identical to the mid-term exam but focusing on the material covered in the second half of the semester. Analysis methods developed in the first half of the semester will have to be used to complete the exam, so it is partly cumulative assessment of learning.

<u>(5%) Posting research project on course blog/website</u>
The final paper will be submitted to Carmen for grading and simultaneously posted on a public-facing website/blog (using u.osu.edu), where comments can be posted on the paper. This will give students a way to reference their work in the future and to interact with the public related to the topic of their paper. This posting constitutes 5% of the final grade. Students will be given full credit when they successfully post their paper.

Grading Scale

93–100: A
90–92.9: A-
87–89.9: B+
83–86.9: B
80–82.9: B-
77–79.9: C+
73–76.9: C
70–72.9: C-
67–69.9: D+
60–66.9: D
Below 60: E

Grading Scale: Marks allowed by rule 3335-8-21 using the guidance on page 9 of the Buckeye Guide to Academic Policies: https://registrar.osu.edu/policies/buckeye_guide_academic_policies_070522.pdf

Other Course Policies

Discussion and Communication Guidelines

The following are my expectations for how we should communicate as a class. Above all, please remember to be respectful and thoughtful.

- **Writing style**: While there is no need to participate in class discussions as if you were writing a research paper, you should remember to write using good grammar, spelling, and punctuation. A more conversational tone is fine for non-academic topics.
- **Tone and civility**: Let's maintain a supportive learning community where everyone feels safe and where people can disagree amicably. Remember that sarcasm doesn't always come across to others.

Ohio State's Academic Integrity Policy

It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term "academic misconduct" includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct http://studentlife.osu.edu/csc

Statement on Title IX

Title IX makes it clear that violence and harassment based on sex and gender are Civil Rights offenses subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories (e.g., race). If you or someone you know has been sexually harassed or assaulted, you may find the appropriate resources at http://titleix.osu.edu or by contacting the Ohio State Title IX Coordinator at titleix@osu.edu

Student Life Disability Services (SLDS) and COVID-19

The university strives to maintain a healthy and accessible environment to support student learning in and out of the classroom. If you anticipate or experience academic barriers based on your disability (including mental health, chronic, or temporary medical conditions), please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion.

If you are isolating while waiting for a COVID-19 test result, please let me know immediately. Those testing positive for COVID-19 should refer to the Safe and Healthy Buckeyes site for resources. Beyond five days of the required COVID-19 isolation period, I may rely on Student Life Disability Services to establish further reasonable accommodations. You can connect with them at slds@osu.edu; 614-292-3307; or slds.osu.edu.

Commitment to a Diverse and Inclusive Learning Environment

The Ohio State University affirms the importance and value of diversity in the student body. Our programs and curricula reflect our multicultural society and global economy and seek to provide opportunities for students to learn more about persons who are different from them. We are committed to maintaining a community that recognizes and values the inherent worth and dignity of every person; fosters sensitivity, understanding, and mutual respect among each member of our community; and encourages each individual to strive to reach his or her own potential. Discrimination against any individual based upon protected status, which is defined as age, color, disability, gender identity or expression, national origin, race, religion, sex, sexual orientation, or veteran status, is prohibited.

Your Mental Health

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student’s ability to participate in daily activities. The Ohio State University offers services to assist you with addressing these and other concerns you may be experiencing. If you or someone you know are suffering from any of the aforementioned conditions, you can learn more about the broad range of confidential mental health services available on campus via the Office of Student Life’s Counseling and Consultation Service (CCS) by visiting ccs.osu.edu or calling 614- 292-5766. CCS is located on the 4th floor of the Younkin Success Center and the 10th floor of Lincoln Tower. You can reach an on-call counselor when CCS is closed at 614-292-5766 and 24 hour emergency help is also available 24/7 by dialing 988 to reach the Suicide and Crisis Lifeline.

Religious Accommodations

It is Ohio State's policy to reasonably accommodate the sincerely held religious beliefs and practices of all students. The policy permits a student to be absent for up to three days each academic semester for reasons of faith or religious or spiritual belief.

Students planning to use religious beliefs or practices accommodations for course requirements must inform the instructor in writing no later than 14 days after the course begins. The instructor is then responsible for scheduling an alternative time and date for the course requirement, which may be before or after the original time and date of the course requirement. These alternative accommodations will remain confidential. It is the student's responsibility to ensure that all course assignments are completed.

Course Schedule

The below schedule roughly follows the outline of the assigned textbook, *Physics and technology for future presidents: An introduction to the essential physics world leader needs to know*, R. A. Muller (Princeton University Press, Princeton, 2010).

Week 1 - Learning Module 1

First Lecture: Introduction, course goals, course products, expectations, how to read the text, a demonstration of one topic.

Assigned reading topic: Energy and power and the physics of explosions – chapter 1

Pre-module reading, Ch. 1 of the text

In-class readiness assurance, beginning of second class, TopHat (ELO 2.2)

Mini-lectures both classes, interspersed with in-class questions to check understanding, TopHat (ELO 3.1)

- What is energy?
- What is power?
- How is energy generated?
- What are the appropriate scaling laws for energy, power, and different sources of energy?
- How can a chocolate cookie have more energy than a stick of dynamite?
- What are the geopolitical implications for energy generation and consumption?
- Introduction to the term research project. Expectations, example projects, how have a topic approved, time in recitations allocated to the project.

No recitation during week 1

Week 2 – Learning Module 2

Assigned reading topic: Atoms and heat – chapter 2

Pre-module reading, Ch. 2 of the text

In-class readiness assurance, beginning of first class, TopHat (ELO 2.2)

Mini-lectures both classes, interspersed with in-class questions to check understanding, TopHat (ELO 3.1)

- What are atoms, and molecules?
- What is heat and temperature?
- Why does heat waste have implications for the energy economy?
- Open discussion of research topic selections, where to find additional resources, format of the one-paragraph topic description.

Recitation: Advanced problem solving on topic related to Learning Module 1 but not yet seen by the students to demonstrate generalization of knowledge (ELO 1.2, ELO 2.1, ELO 3.1). Team problem solution scratch cards turned in at the end of recitation. Discuss research topic selection and implications for one-paragraph touch point due the following week.

Week 3 – Learning Module 3

Assigned reading topic: Gravity, force, and space – chapter 3

Pre-module reading, Ch. 3 of the text

In-class readiness assurance, beginning of first class, TopHat (ELO 2.2)
Mini-lectures both classes, interspersed with in-class questions to check understanding, TopHat (ELO 3.1)

- The force of gravity
- Orbiting the Earth
- Air Resistance and Fuel Efficiency with implications for global warming
- Momentum
- Rockets
- Airplanes, helicopters and Fans
- Convection – Thunderstorms and Heaters
- Reminder of the research topic selection paragraph due date, solicit questions from the class.

Recitation: Advanced problem solving on topic related to Learning Module 2 but not yet seen by the students to demonstrate generalization of knowledge (ELO 1.2, ELO 2.1, ELO 3.1)

Research project touchpoint 1: Submit one-paragraph on topic choice, a minimum of three sources for the project. Not graded. Feedback provided to students within 1 week.

Week 4 – Learning Module 4

Assigned reading topic: Nuclei and radioactivity – chapter 4
Pre-module reading, Ch. 4 of the text
In-class readiness assurance, beginning of first class, TopHat (ELO 2.2)
Mini-lectures both classes, interspersed with in-class questions to check understanding, TopHat (ELO 3.1)

- Radioactivity, including medical imaging and cancer therapy
- Fission
- Fusion, the dream and the hype, including the recent wave of startup companies
- Finding other sources for the research topic, where to search in the library, online repositories, etc.

Recitation: Advanced problem solving on topic related to Learning Module 3 but not yet seen by the students to demonstrate generalization of knowledge (ELO 1.2, ELO 2.1, ELO 3.1). Find at least one additional source for research topic, identify at least one scaling law that will be used in the project.

Week 5 – Learning Module 5

Assigned reading topic: Chain reactions, nuclear reactors, and atomic bombs – chapter 5
Pre-module reading, Ch. 5 of the text
In-class readiness assurance, beginning of first class, TopHat (ELO 2.2)
Mini-lectures both classes, interspersed with in-class questions to check understanding, TopHat (ELO 3.1)

- Chain reactions
- Nuclear weapons and dirty bombs
- Nuclear reactions, the cost of building a commercial reactor, implications for energy policy
- Nuclear waste, how to keep it safe over 1,000's of years

- Nuclear fusion, the dream and the hype, including the recent wave of startup companies
- Expectations for the one-paragraph description of at least one scaling law that will be used in the research project.

Recitation: Advanced problem solving on topic related to Learning Module 4 but not yet seen by the students to demonstrate generalization of knowledge (ELO 1.2, ELO 2.1, ELO 3.1). Find at least one additional source for research topic, identify at least one additional scaling law that will be used in the project.

Research project touchpoint 2: Submit one-paragraph the primary scaling laws that will be used in the research topic. Not graded. Feedback provided to students within 1 week.

Week 6 – Learning Module 6

Assigned reading topic: Electricity and magnetism – chapter 6
Pre-module reading, Ch. 6 of the text
In-class readiness assurance, beginning of first class, TopHat (ELO 2.2)
Mini-lectures both classes, interspersed with in-class questions to check understanding, TopHat (ELO 3.1)

- What is electricity and magnetism?
- Electricity, electrical power
- Magnets
- Electromagnetic fields
- Electric motors and generators, electric cars
- Transformers
- Magnetic levitation, the dream of superconductors
- AC vs DC electricity
- Discuss the mechanisms for writing the research paper, such as Word. Go over paper template provided on Carmen. Discuss sections, entering equations.

Recitation: Advanced problem solving on topic related to Learning Module 5 but not yet seen by the students to demonstrate generalization of knowledge (ELO 1.2, ELO 2.1, ELO 3.1)

Week 7 – Midterm Preparation

Review session first lecture of the week; take in-class exam during second lecture of the week

Recitation: Advanced problem solving on topic related to Learning Module 6 but not yet seen by the students to demonstrate generalization of knowledge (ELO 1.2, ELO 2.1, ELO 3.1). Verify that all students can download research paper template, set aside time for setting up and performing scaling analysis for the project, ask questions of the teaching assistant and peer teammates.

Week 8 – Learning Module 7

Assigned reading topic: Waves Including UFOs, Earthquakes, and Music – Chapter 7
In-class readiness assurance, beginning of first class, TopHat (ELO 2.2)
Mini-lectures both classes, interspersed with in-class questions to check understanding, TopHat (ELO 3.1)

- What is wave?

- Communication
- Why does the ground shake?
- Does a gold flute play better music?
- Expectations for citing works in the physical sciences and how to enter citations using Word.

Recitation: Continue to work on scaling analysis for the research project, ask questions to the teaching assistant and peer teammates, begin to write up the one-paragraph analysis.

Research project touchpoint 3: Submit one-paragraph summarizing the analysis completed to date related to the research topic. Not graded. Feedback provided to students within 1 week.

Week 9 – Learning Module 8

Assigned reading topic: Light – chapter 8
Pre-module reading, Ch. 8 of the text
In-class readiness assurance, beginning of first class, TopHat (ELO 2.2)
Mini-lectures both classes, interspersed with in-class questions to check understanding, TopHat (ELO 3.1)

- What is light?
- Color
- Images
- Mirrors and Lenses
- Eyes and vision
- Telescopes and Microscopes
- Diffraction
- Holograms
- Polarization
- Discuss expectations for arriving at implications for future leaders related to the research topic

Recitation: Advanced problem solving on topic related to Learning Module 7 but not yet seen by the students to demonstrate generalization of knowledge (ELO 1.2, ELO 2.1, ELO 3.1). Discuss implications of their research topic with peer teammates and with teaching assistant.

Week 10 – Learning Module 9

Assigned reading topic: Invisible Light – chapter 9
Pre-module reading, Ch. 9 of the text
In-class readiness assurance, beginning of first class, TopHat (ELO 2.2)
Mini-lectures both classes, interspersed with in-class questions to check understanding, TopHat (ELO 3.1)

- Thermal light and seeing in the dark
- Ultraviolet light – black light parties and killing germs
- The Ozone layer
- Electromagnetic radiation
- Medical Imagine
- Not light: sonar (bats and submarines)
- Solicit questions about the research topic, all aspects of the topic.

Recitation: Advanced problem solving on topic related to Learning Module 8 but not yet seen by the students to demonstrate generalization of knowledge (ELO 1.2, ELO 2.1, ELO 3.1). Draft paragraph summarizing the implications of their topic for future leaders. Get feedback on the paragraph from peer teammates.

Research project touchpoint 4: Submit one-paragraph summarizing the implications of their topic for future leaders. Not graded. Feedback provided to students within 1 week.

Week 11 - Learning Module 10

Assigned reading topic: Climate change – chapter 10
Pre-module reading, Ch. 10 of the text
In-class readiness assurance, beginning of first class, TopHat (ELO 2.2)
Mini-lectures both classes, interspersed with in-class questions to check understanding, TopHat (ELO 3.1)

- Global Warming
- Solutions

Recitation: Advanced problem solving on topic related to Learning Module 9 but not yet seen by the students to demonstrate generalization of knowledge (ELO 1.2, ELO 2.1, ELO 3.1). Work on research topic, all aspects.

Week 12 – Learning Module 11

Assigned reading topic: Quantum physics – chapter 11
Pre-module reading, Ch. 11 of the text
In-class readiness assurance, beginning of first class, TopHat (ELO 2.2)
Mini-lectures both classes, interspersed with in-class questions to check understanding, TopHat (ELO 3.1)

- Electron waves
- The LASER
- Semiconductor Transistors
- Electron Microscope
- Tunneling
- Quantum Computers – a game changer?
- Open questions on research paper, poll students on progress using TopHat.

Recitation: Advanced problem solving on topic related to Learning Module 10 but not yet seen by the students to demonstrate generalization of knowledge (ELO 1.2, ELO 2.1, ELO 3.1)

Week 13 – Learning Module 12

Assigned reading topic: Relativity – chapter 12
Pre-module reading, Ch. 12 of the text
In-class readiness assurance, beginning of first class, TopHat (ELO 2.2)
Mini-lectures both classes, interspersed with in-class questions to check understanding, TopHat (ELO 3.1)

- Time Dilation
- Lorentz Contraction
- Relative Velocities

- General Relativity – a Theory of Gravity
- Questions about Time
- Review expectations for research paper, reminder of due date.

Recitation: Advanced problem solving on topic related to Learning Module 11 but not yet seen by the students to demonstrate generalization of knowledge (ELO 1.2, ELO 2.1, ELO 3.1)

Final research paper due at the end of the week.

Week 14 – Learning Module 13

Assigned reading topic: The Universe – chapter 13
Pre-module reading, Ch. 13 of the text
In-class readiness assurance, beginning of first class, TopHat (ELO 2.2)
Mini-lectures both classes, interspersed with in-class questions to check understanding, TopHat (ELO 3.1)

- The solar system
- Galaxies
- Seeing the past
- Expansion of the universe
- Dark Energy
- The Big Bang
- Theory of everything
- Discuss expectations for posting paper on course website/blog.

Recitation: Advanced problem solving on topic related to Learning Module 12 but not yet seen by the students to demonstrate generalization of knowledge (ELO 1.2, ELO 2.1, ELO 3.1). Verify that students can access their website/blog for their paper

Week 15 – Learning Module 14

Assigned reading topic: Quantum Computing (Carmen course material reading)
Pre-module reading, Carmen course material reading
In-class readiness assurance, beginning of first class, TopHat (ELO 2.2)
Mini-lectures both classes, interspersed with in-class questions to check understanding, TopHat (ELO 3.1)

- What is a qubit?
- Why can a classical computer factor large numbers?
- Simulating quantum systems – drug discovery, logistics
- The hype cycle for quantum computing

Recitation: Advanced problem solving on topic related to Learning Module 13 but not yet seen by the students to demonstrate generalization of knowledge (ELO 1.2, ELO 2.1, ELO 3.1). Upload paper to website/blog.

Week 16 – Final Exam Preparation

Wrap up of the semester, where have we been (1 class)
Review of the material for the final exam (1 class)

No recitation

Final exam during the period set by the registrar

How this course connects to or exemplifies the concepts of this Theme (Number, Nature, Mind):

The relation between mathematics and physics is profound, leading to quantitative predictions of the world around us. While it can take years to master these mathematical theories, much headway can be made by learning basic physics concepts and how the underlying theory depends on physical quantities – known as scaling laws. Using physics concepts and scaling laws, students in this course will explore a variety of problems of societal importance, including energy security and sustainability, global warming, information, imaging, and space technologies, radiation physics, quantum physics, machine learning, and exploring the universe. This approach will establish an important knowledge base for future leaders of the United States government, companies, boards, or non-government organizations, who must adapt to an ever-changing world where technologies play a critical role.

ELO 1.1 Students will engage in critical and logical thinking about physics and technology by using the mathematical scaling laws that underly the physical theories. For each major course topic, students will have multiple engagements with the scaling laws:

1) They will learn the basic concepts and scaling laws through *pre-lecture readings* from the text and other on-line resources;

2) At the beginning of each class, they will take a brief quiz – known as a "readiness assurance assessment," to verify that they have prepared for the lecture (counts towards 20% of the course grade);

3) During lecture, there will be multiple pauses for them to consider a problem in small teams and answer a "clicker question," where the lecture content will be adjusted based on the outcome of the clicker question (does not count toward course grade);

4) During weekly recitation, they will be guided by a teaching assistant through relevant estimation problems using the appropriate scaling laws, completed in a small team setting (20% of course grade);

5) Every two weeks, they will identify a short article or video on a relevant science or technology topic, analyze the topic using scaling laws, and write a brief (~1 page) critique to assess the correctness of the article and the implications of the topic for future leaders (20% of the course grade);

6) They will apply scaling laws to a few problems during a mid-term and final exam (20% of the course grade).

ELO 1.2 Students will engage in an advanced, in-depth, scholarly exploration of the ideas and concepts learned in this course using the same structure described in 1.1 above. The engagements and assessments are "advanced" because the students will be asked to apply their gained knowledge to problems they have not seen before, demonstrating knowledge generalization. Point 5) above, where students will identify a media piece of interest to them is a key skill they will take away from the course. Here, they will assess the piece to help understand the prevalence of science and technology embellishment or inaccuracy that is becoming more prevalent. Assessment of knowledge attainment will be through a progressive, scaffolded approach. They will be assessed with low-stakes quizzes in class and problem solving in recitation so they will be prepared to demonstrate advanced problem solving and analysis during the exams.

ELO 2.1 Students will identify, describe, and synthesize approaches or experiences by applying their knowledge to problems they have not seen previously. Especially important in this regard will be using their knowledge to assess claims in the bi-weekly media stories/videos of their choosing. They will be encouraged to identify stories/videos that are of interest to them and related to the current course topic. They will be expected to assess both the strengths and weakness of the work using the mathematical techniques develop in class and to give opposing viewpoints in their ~1 page write up.

ELO 2.2 Students will demonstrate a developing sense of self as a learner through reflection, self-assessment and creative work, building on prior experiences to respond to new and challenging contexts throughout the course. For example, they will respond to questions posed during class by working in small teams and then entering their answer through a polling system. The overall class will discuss the results of the poll and reflect on why other teams arrived at different answers. In the recitations, they will work in teams to analyze different problems related to the current course topic, but problems they have not seen before. They will be guided to reflect on their approach to solving these problems to arrive at a systematic method for approaching unknown problems. As an individual, they will find a media story/video related to science/technology/policy and perform a critical assessment of the science underlying the story/video. They will then reflect on how they would integrate this knowledge to make decisions in a possible future leadership role.

ELO 3.1 Students will analyze and describe how mathematics functions as an idealized system that enables logical proof and/or as a tool for describing and understanding the natural world using scaling laws. Scaling laws are a powerful approach for learning the underlying physics concepts and applying them to various problems. Such scaling laws are often not taught or emphasized in upper-level physics courses even though these courses usually delve into the full mathematical theories. This course will up-end the standard pedagogical approach in the physics discipline by starting with the concepts and scaling laws and showing how this approach can give key insights. In fact, most science and technology experts use the approach taken in this course to do a quick assessment of a problem or claim, yet it is usually learned only through practical experience. Throughout the semester, students will learn how to critique scientific claims using scaling law. For example, one recent claim is that a solar farm with an area of 22 square miles would be enough to satisfy the power demands of the United States. This claim can be assessed knowing the solar radiation flux at the surface of the Earth and how the power generated by a solar panel scales with the area of the panel. To take the problem further and give the problem further richness, students will predict the loss of power over transmission lines by knowing the scaling of this loss with distance and the distance scale of the United States.

Research and Creative Inquiry Course Inventory

Overview

The GE allows students to take a single, 4+ credit course to satisfy a particular GE Theme requirement if that course includes key practices that are recognized as integrative and high impact. Courses seeking one of these designations need to provide a completed Integrative Practices Inventory at the time of course submission. This will be evaluated with the rest of the course materials (syllabus, Theme Course submission document, etc). Approved Integrative Practices courses will need to participate in assessment both for their Theme category and for their integrative practice.

Please enter text in the boxes below to describe how your class will meet the expectations of Research and Creative Inquiry courses. It may be helpful to consult with the OSU Office of Undergraduate Research and Creative Inquiry. You may also want to consult your Director of Undergraduate Studies or appropriate support staff person as you complete this Inventory and submit your course.

Please use language that is clear and concise and that colleagues outside of your discipline will be able to follow. You are encouraged to refer specifically to the syllabus submitted for the course, since the reviewers will also have that document. Because this document will be used in the course review and approval process, you should be *as specific as possible*, listing concrete activities, specific theories, names of scholars, titles of textbooks etc.

Accessibility

If you have a disability and have trouble accessing this document or need to receive it in another format, please reach out to Meg Daly at daly.66@osu.edu or call 614-247-8412.

Pedagogical Practices for Research and Creative Inquiry Courses

Course subject & number	Physics 2100

Undergraduate research is defined by the Council on Undergraduate Research (CUR) as an inquiry or investigation conducted by an undergraduate student that makes an *original* intellectual or *creative* contribution to the discipline. Undergraduate creative activity is the parallel to research, engaging in a rigorous creative process using (inter)disciplinary methods to produce new work.

In the context of the 4-credit GEN Theme High Impact Practice (which, by definition, is a more robust course than a non-HIP 3-credit Theme course—since student will take one 4-credit course instead of taking two 3-credit courses), research or creative inquiry requires a level of rigor and engagement that goes beyond what is routinely already included in a 3-credit Theme course in that discipline. It will generally mean that students are either (1) instructed in and engage in original research and the production and/or analysis of new understanding or data used in the preparation of a final paper, report, or project characteristic of the discipline, *or* (2) they are instructed in and engage in the primary production and performance or display of new creative work characteristic of the discipline.

Further comments and clarifications:

- The Creative Inquiry or Research component should be integrated throughout a *substantial* portion of the course (not just at the very end, for example).
- The Creative Inquiry or Research component should connect to the Theme and to the subject/content of the course. If the course at hand is requesting two Themes, then the research component or creative work should fully pertain to both Themes.

1. <u>Disciplinary expectations and norms</u>: Different disciplines at the university define original research and creative inquiry differently. Please explain what the expectations/norms of your discipline are for original research or creative inquiry. How is new understanding developed in your field? How does the creative process amplify knowledge in the field? (This information should also be readily visible on the syllabus.)

The physics discipline is a quantitative science that uses mathematics as the language for underlying theories and analysis of problems. For most research projects in the discipline, it is expected that students will use mathematical analysis of the theories to support the claims of the study. What is challenging for students is that there are apparently many theories, and it is challenging for them to take the right approach.

Rather than expecting that students can derive the mathematical theories, they will be taught so-called scaling laws, which specifies how a physical prediction scales with variation in an underlying quantity on which the theory depends. For example, for a solar energy panel, the power produced by the panel scales with the solar constant, the atmospheric transmission, the area of the panel (assuming it is oriented toward the Sun), and the device efficiency. Using algebra only, students can determine the area of a solar array needed to supply the citizens of the United States with power if they were to research the current daily energy consumption and knowing the number of seconds in a day.

Another research expectation is that students can interpret the result of their analysis in the context of their research claims. This goes beyond pure mathematics and gives physical insight to the analysis.

For all research problems, students will be expected to identify the appropriate scaling laws for their topic and use them to make quantitative predictions related to their topic. Furthermore, they will be required to interpret their results and use it for a critical analysis of their research topic. This is described in item 10.b and 10.c of the Research Project Description in the course syllabus.

2. <u>Teaching methods and practices</u>: Which class activities and materials will be used to <u>teach</u> students the research methodology and/or research practices or the methods and practices of creative inquiry typical or relevant in your discipline? How will the potential ethical implications for research or creative inquiry in the field be addressed in the course? (This information should also be readily visible on the syllabus.)

The core part of the course is to teach students physical scaling laws for problems outlined in the Weekly Topics (syllabus item 15), how to use them to make quantitative predictions, and to interpret the results. The topics will be introduced in lectures (using team-based activities with in-class polling as check-points) and they will apply these concepts to new related problems in weekly recitation guided by teaching assistants.

Beyond the topic analysis, the physics discipline has expectations for the writing style for presenting research results, which includes an introduction and motivation for the topic, statement of the problem, introducing the scaling laws, outlining the analysis, interpretation of the results, and a discussion/conclusion. Cited works are expected to appear in the body text as they are used. An important creative aspect of the research topic is to create a "storyboard" graphic for the paper introduction. Here, the graphic is a way to visualize the entire project and is found in high-profile journals intended for a general audience. Beginning researchers in the discipline usually find creating a storyboard challenging because they often get lost in the details of the project. Yet, for future leaders, thinking about how to succinctly summarize a complex topic using a single graphic is an important skill.

Students will be taught the scientific writing style throughout the course, so they are prepared to write a high-quality paper on their research topic. Time will be devoted in class and recitations to teach them the basic writing tools, such as using Microsoft Word, the Equation Editor, and the end-of-paper Reference manager, for their paper.

Also, students will consult with the recitation instructor and their recitation team mates to make sure they are on track using the appropriate scaling laws for their topic and how to use them for making predictions.

Regarding ethical aspects of the material, students will be confronted with problems that do not have a known or accepted answer. As a future leader, the science underlying a topic is only one point to consider. There are social and political points that must be considered before a leader can decide on a course of action. These ethical considerations will be discussed in every lecture and historical examples will be discussed in the context of the environment in which a decision was made in the past and how changes in the world might give rise to a different decision. The course will not push one outcome over another; the goal is to make sure the science analysis is done correctly and present all sides of an issue beyond the science. It is up to the students to arrive at and defend a particular decision/course of action.

3. Implementing: Through which class activities and materials will the students be given opportunities to practice disciplinary research or creative inquiry techniques, methods, and skills to create new knowledge or advance praxis? (This information should also be readily visible on the syllabus.)

There are multiple and repeated opportunities for students to practice the research activities they need to complete their research topic.

In class, they will work in small teams to answer questions related to the lecture topic and enter their results using a polling system. The instructor will use the poll results to either move on to the next topic or to address problems or misconceptions (Just-In-Time teaching pedagogy). Also, each weekly topic will start with a storyboard graphic and students will be asked in-class questions as a critique of the graphic.

In recitation, students will work in small teams to decide on appropriate scaling laws and apply them to problems they have not seen but are related to the weekly topic. They will also be expected to interpret their results. The work will be completed during the recitation section, where there will be group report-out of results.

In each weekly recitation session, students will be given 30 minutes to work on their research topic. Depending on the upcoming research topic deadline, they will be given an opportunity to ask their teammates or recitation instructor questions about their research topic, such as a critique of their draft storyboard, whether a scaling law is appropriate for their topic, how to apply the scaling law to their problem, etc. Or, there will be minilectures demonstrating how students can use Microsoft Word for writing their paper.

A discussion of these activities appears throughout the syllabus.

4. <u>Demonstration of competence</u>: Disciplines develop and share new knowledge or creative work in different ways. Through which activity or activities will students first be taught and then be involved in a demonstration of competence in an appropriate format for the discipline (e.g., a significant public communication of research, display of creative work, or community scholarship celebration)? The form and standard should approximate those used professionally in the field. (**This information should also be readily visible on the syllabus.**)

The primary form of disseminating research results in physics is through a written paper, and this is the format for the research topic product for this course. Public dissemination of papers is currently accomplished through posting the manuscript on a pre-print server, submission to a journal for review, and then archival publication in the journal.

As discussed above, students will be given instruction on the format and mechanisms of writing a paper appropriate for the physics discipline.

For many younger physics researchers, disciplinary blogs play an increasing important mechanism to disseminate research results. To this end, there will be a public course web site created on the university portal **u.osu.edu** in addition to the private Carmen course site. Each year, the student research topic papers will be posted on the public site as a PDF document but embedded in the blog format so that anyone can post questions or comments on the paper. It will be up to the students to screen and respond to outside inquires.

5. <u>Scaffolding and mentoring</u>: Explain how the creative inquiry or research project will be scaffolded across multiple assignments or one large project broken up across the course (e.g., specific explanations about reviewing literature, developing methods, collecting data, interpreting or developing a concept or idea into a full-fledged production or artistic work). Each pertinent assignment should help students build and demonstrate skills contributing to the larger project. Meaningful feedback and mentoring should be provided by the instructor at regular intervals to inform next steps in the process. (This information should also be readily visible on the syllabus.)

Scaffolding the research topic work and writing the research paper is known to be important to achieve good learning outcomes. Thus, scaffolding is deliberately built into the course syllabus in the form of regular "touch points" during the semester. Here, students are required to submit a brief written document that moves them along the research process so that they don't wait until the last minute and then find that they don't have the time to complete a meaningful research topic. The instructors will provide feedback on each of these submissions. See syllabus entry 5.d.

6. <u>Reflection</u>: Explain how the course offers students opportunities for reflection on their own developing skills and their status as learners and as researchers or creatives. (This information should also be readily visible on the syllabus.)

The final part of the research paper is a reflection on their analysis and interpretation of results. Students are asked to place this reflection in the context of a future leader. Here, they will go beyond the science of a topic and bring in current social or political viewpoints to help them arrive at how they would decide on an issue or chart a course of action if they were a future leader or an advisor to a future leader. See syllabus item 10.d.