Overview and Goals

The goal of this series of summer workshops is to prepare a group of monastics to become science instructors at their respective institutions. The scope of this syllabus is the workshop sessions dedicated to physics teaching and learning. It is assumed that the monastic students have already studied physics, such as through being Tenzin Gyatso Science Scholars at Emory University or completing the first four years of the ETSI curriculum. The workshops will both deepen physics content knowledge and provide pedagogical training, facilitating the development of the monastics' confidence to be science teachers and giving them tools to be effective in the classroom.

Students Learning Outcomes

At the end of the 3 year program, students will be able to:

1. Develop and deliver a lesson on a physics topic using multiple effective teaching techniques
2. Appraise their own understanding of key physics topics and identify resources to improve and extend that understanding
3. Analyze physics applications from biology, neuroscience, and every day life, constructing an explanation using physics terminology and models
4. Critique explanations of physical phenomena, identifying common misconceptions and incorrect reasoning
5. Identify cross-cutting physics concepts and important quantitative skills

Anticipated Student Preparation

Students should be familiar with the content delivered in the first four years of the ETSI physics curriculum (at minimum) such that they can read the textbook on their own to re-familiarize themselves with key terminology and concepts. It is not expected that the monastics have mastery over this material. We anticipate that students are comfortable with quantitative skills such as variable use, basic plot creation and interpretation, and scientific notation.

Content and Structure

Each year's workshop will focus on one cluster of physics topics, typically aligned with the structure from the existing ETSI curriculum, with a different primary teaching technique emphasized each year. The instructional methods will be utilized in the content-focused sessions, and will be explained and justified in the pedagogy-focused sessions. Key themes, such as energy, will be emphasized so provide the monastics with a broader perspective on physics as a discipline.

Year	Physics Topic	Teaching Technique
1	Mechanics	Inquiry-Based Learning
2	Electricity and Magnetism	Interactive Lecture Demonstrations
3	Matter, Thermodynamics, Waves	Peer Instruction

Year 1

An overview of physics education research will be presented, focusing on the techniques used to assess effective teaching techniques. A brief assessment (such as the Force Concept Inventory, possibly truncated) will be administered at the beginning and end of the course. This will be used to assess the monastics' prior knowledge and content learning from this workshop, as well as modeling assessment for the monastic students. They will be shown how to analyze and interpret these assessment data, such as calculating learning gain.

The physics content focus will be mechanics, reviewing and extending what is presented in the second year of the ETSI physics curriculum. This covers chapter 2 through 10 of Paul G. Hewitt's *Conceptual Physics*, 11th Ed. The "content delivery" will primarily be through inquiry-based learning activities, the design and goals of which will be explicitly presented. A key topic is energy conservation, which appears often in physics and is also important in the biosciences. Pedagogical training will include the use of inquiry-based learning and common student misconceptions in mechanics.

Year 2

This covers the *fourth* year of the ETSI physics curriculum, covering chapters 22 through 27: electrostatics, circuits, magnetism, and light. This is planned to appear in the second year due to the importance of the topics in understanding neuroscience research techniques. These topics naturally yield themselves to many in-class demonstrations and hands-on activities. Class sessions will utilize the approach of Interactive Lecture Demonstrations, where students predict, model, and explain the demonstrations performed. This will utilize color response cards and will also introduce whiteboarding.

Year 3

The physics content will cover what is presented in the third year of the ETSI physics curriculum, covering chapters 11 through 21: properties of matter, heat, thermodynamics, waves, and sound. Class sessions will heavily use Peer Instruction, utilizing color response cards to facilitate think-pair-share type activities. More advanced questions will have monastics participate as themselves, but they will also be asked to role play as students (anticipating student misconceptions) for some questions. Monastics will discuss similarities and differences between Peer Instruction techniques and traditional Buddhist debate. Other pedagogical strategies and tools, such as simulations, may be implemented based on the experiences and progress of the first two years.

Workshop Structure

The workshop will consist of 8 days of instruction, with each day having three 90-minute teaching sessions. The two morning sessions will be focused on physics content, and the afternoon session will be focused on pedagogy. These two aspects will be integrated as much as possible, utilizing target pedagogies in the morning and dissecting aspects of the morning lessons as concrete examples in the afternoon. Slides and printed materials will be dual-language, with students receiving hard copies and having access to the files.

Monastics will be asked to read the relevant chapters in Hewitt and review other available materials (on http://www.emorytibetscienceinitiative.com) before the beginning of the workshop. Students will submit a short list of questions they have on the material, as well as one specific application of the material to biology, neuroscience, or every day life. The first few days of the workshop will then present the topic utilizing the targeted teaching technique. Later in the workshop, students will be asked to write written explanations of physics concepts, such as why a certain answer is correct on a multiple choice test. Monastics will then work in small groups to critique each others' written responses, discussing whether the explanation is correct and how it can be improved.

Part of the way through the workshop, students will form small groups to design their own lessons. Each group will present on a focused topic, such as addressing one of the questions raised by students at the beginning of the week. The short lesson will be designed to utilize the pedagogical techniques presented, with monastics responsible for designing and implementing appropriate activities. All lessons will be presented in class to all students at the end of the workshop.

Potential Resources

The following texts and resources may be utilized in two different ways. Selections from these will be presented in the workshop, both for in-class activities and pedagogical resources. Where possible, important explanatory text and example activities will be translated into Tibetan and made available online. Additionally, students will be provided with a list of resources, primarily online, to help them further develop their content and pedagogical knowledge while they prepare to teach in their own classrooms.

The following list is preliminary and is under revision.

- S. A. Ambrose, M. W. Bridges, M. DiPietro, M. C. Lovett, M. K. Norman, and R. E. Mayer. *How Learning Works: Seven Research-Based Principles for Smart Teaching.* Jossey-Bass, San Francisco, CA, May 2010
- E. F. Barkley. *Learning Assessment Techniques: A Handbook for College Faculty.* John Wiley & Sons, San Francisco, CA, Jan. 2016
- D. Bruff. *Teaching with Classroom Response Systems: Creating Active Learning Environments.* Jossey-Bass, San Francisco, Feb. 2009
- R. D. Knight. *Five Easy Lessons: Strategies for Successful Physics Teaching.* Pearson, San Francisco, Calif., Sept. 2002
- E. Mazur. *Peer Instruction: A User's Manual.* Pearson, Upper Saddle River, N.J, Aug. 1996

- L. K. Michaelsen, A. Bauman Knight, and L. D. Fink, editors. *Team-Based Learning: A Transformative Use of Small Groups in College Teaching*. Stylus Publishing, Sterling, Va, Feb. 2004
- J. B. Nelson and J. Nelson. *Teaching About Kinematics*. American Association of Physics Teachers, Jan. 2009
- T. L. O'Kuma, D. P. Maloney, and C. J. Hieggelke. *Ranking Task Exercises in Physics*. Prentice Hall, Upper Saddle River, NJ, Aug. 1999
- J. Pizzo. *Interactive Physics Demonstrations: A Collection of Deck the Halls Columns and Other Articles Reprinted from the Physics Teacher 1972-2001*. Amer Assn of Physics Teachers, Jan. 2002
- D. R. Sokoloff and R. K. Thornton. *Interactive Lecture Demonstrations, Active Learning in Introductory Physics*. Wiley, Hoboken, NJ, Sept. 2006
- H. D. Thier and B. Daviss. *Developing Inquiry-Based Science Materials: A Guide for Educators*. Teachers College Press, New York, July 2001
- Compadre.org Homepage. URL `https://www.compadre.org/`
- The Physics Teacher. URL `https://aapt.scitation.org/journal/pte`