Teaching Dossier
of
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1. Biographical Background

I am currently a postdoctoral scholar in physics at the California Institute of Technology (Caltech), and a Visiting Affiliate at the NASA Jet Propulsion Laboratory in Pasadena, California where my research focuses on foundational questions in quantum mechanics, quantum gravity, and cosmology. I pursued my PhD at the California Institute of Technology from 2015 to 2020 where I was a teaching assistant (TA) and instructor for a variety of undergraduate physics courses spanning the core curriculum of Classical Mechanics, Electromagnetism, Special Relativity, Vibrations & Waves, Quantum Mechanics, and Statistical Mechanics & Thermodynamics. I was a teaching assistant for and/or taught classes for a total of 4 school years of my 5 years as a PhD candidate, with responsibilities ranging from engaging in full lecture-style recitation instruction, to grading, formulating homework & exam problems, and being the head TA (managing course logistics).

Teaching forms a core part of how I connect with physics. I was conferred awards for excellence in teaching by both the student body, the Associated Students of Caltech (ASCIT) in 2018, and the R. Bruce Stewart Prize by the Caltech Physics Department in 2019. I also served as the Physics Teaching Fellow at Caltech for the 2019-2020 academic year where my primary goal was to serve as a resource for other TAs in the department by organizing and leading various teaching workshops and discussion sessions. The course on "Vibrations and Waves" I co-taught with Prof. Frank Porter at Caltech during the Fall of 2019 was video recorded and subsequently offered online as a self instruction course (http://www.waves.caltech.edu) with complete set of homework and exam problems & solutions for audiences beyond Caltech.

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2. Statement of Teaching Experience and Philosophy

As a young theoretical physicist, I found only one thing that can rival — more so, complement, the feeling of awe I feel at Nature's design: the pleasure of sharing with others the excitement of probing the depths of the universe through the lens of physics. I am interested in taking up a professorial role in academia where I can be a fervent physics teacher in the classroom complemented by being an active researcher in areas of quantum mechanics, cosmology, gravitation, and high-energy theory.

As an early career faculty member, I understand one of my primary duties will be to make the physics classroom as vibrant and rewarding for students — something I feel very strongly for. In my time as a graduate student at Caltech, I had a unique and transformative teaching experience. While for most graduate students around me, the academic experience revolved primarily around research, I got a chance to witness "best of both worlds". What usually gets labeled as "due to lack of funding in theoretical physics" for most, my reasons to be a teaching assistant and instructor

found their roots in a deeper connection and passion for teaching. The opportunity to engage in full lecture-style and recitation teaching for over 4 years allowed me to connect with my students at an early stage in my career. I was able to implement a holistic learning environment where the focus is not only on the physics but also how each student is able to resonate with it. Every class has a wide spectrum of students from different backgrounds, academic and otherwise. Part of the fun of teaching physics is to inspire awe for Nature's design, and offer something substantial in it for everyone. To this end, I am reminded of the Introductory Classical Mechanics course I taught for Caltech freshmen in 2017. It was very rewarding to be able to complement what was a grounded discussion of vectors in Newton's Laws with a broader, yet approachable connection to the Einstein's General Relativity for those adventurous students in class eager to push the boundaries.

I have taught a wide variety of classes spanning the undergraduate core curriculum, from Classical Mechanics, Electromagnetism, Special Relativity to Quantum Mechanics, Statistical Physics, and Thermodynamics. My teaching style is informed by both traditional strokes and more modern evidence-based pedagogical practices. I greatly enjoy teaching physics the old-school way, creating magic at the chalkboard, and further strengthening it by interactive problem solving and active-learning discussions. I firmly believe a strong exposition of physical concepts is key to ignite the student's interest in the subject matter which then gets translated into strong problem solving skills. My lectures are structured around exploring core ideas in the subject backed by both mathematical rigor and intuition, while never losing sight of the big picture. Interspersed along the way, a wealth of instructive examples, discussions of real-world applications, and oftentimes a mention of historical roots of the subject gives the students a firm context on how and why those abstract equations describe the world we live in. I back this strategy by keeping my class highly interactive and discussion oriented. At every step of the way, I encourage students to think critically, emphasizing the importance of "thinking like a physicist," rather than just wanting to get to the right answer. This is done by raising conceptual questions (based on the idea of the "force concept inventory") which the class is then encouraged to discuss in small groups or with the person sitting next to them (along the lines of the "think-pair-share" technique). I continually seek student feedback in the class, making sure everyone is onboard and parallel with the pace of the class. I also take ample breaks in between concepts to give students the time and space to absorb material and ask questions. To reiterate the power of standard, textbook material, I often illustrate "cool" concepts with quirky demonstrations such as measuring the storage capacity of a DVD disk by studying a laser's diffraction pattern through it, or measuring the speed of light by studying nodes in a melting chocolate bar in a microwave.

In addition to traditional classroom teaching, we successfully developed and implemented "flipped-section" formats. Once a week, instead of attending the standard lecture, students would meet in an interaction space and would work in small groups, aided by informal discussions with the instructor, to brainstorm on a set of problems covering concepts recently taught in class. The questions for these flipped sections are deliberately and carefully designed to allow students not only get practice in problem solving but also to work on more challenging and rewarding problems. This makes students comfortable and confident with problem solving, while encouraging collaboration and the ability to think outside the box. These flipped sessions complemented with a strong lecture component got a very positive response from the students.

In the spirit of student-centric teaching, I highly value student feedback, and consequently adapt my classes to reflect better teaching practices. While my student evaluations and feedback have been overwhelmingly positive, I have often modulated my lecture pace based on the input I get

from my students. I also actively gauge possible improvements in teaching style along with content organization and exposition based on subtle indicators in the class (such as students' reactions and questions), something that might not show up in student feedback but can be noticed by an experienced instructor. For example, while teaching the sophomore course on Vibrations and Waves, we noticed a certain discomfort the class had with complex numbers and differential equations despite having had introductions to these topics in their math classes. I re-organized the content and spent two sessions with the class brushing up on these topics using a lot of examples, after which their engagement with the physics content increased dramatically.

Complementing my teaching role, I have often been appointed the head teaching assistant (TA), managing and developing course logistics and have also had extensive experience in grading and formulating interesting problems for exams and home-works. To further my commitment to teaching, the Physics Department at Caltech, in addition to my classroom teaching role, also appointed me as Physics Teaching Fellow for the 2019-2020 academic year. My focus as Teaching Fellow was to evolve and better integrate the existing teaching setup by developing evidence-based pedagogical practices. By being a bridge between instructors and the department, I wanted to make sure that physics was not "just another subject" for students, but rather something they would keenly look forward to. I also initiated a discussion with faculty on looking into more broader structural changes to our larger undergraduate courses so as to make them more amenable to the learning needs of students, such as a wider adoption of flipped section format. As a resource for other teaching assistants, I organized a range of TA trainings and workshops on leading recitations, flipped sections, grading, etc. to make sure we all had access to resources and ideas to be able to better connect with our students. I believe good and sincere teaching has to be backed by strong structural components in our academic institutions, something I intend to further work towards in my role as a faculty. I look forward to collaborating with fellow instructors to further build on, and experiment with active learning and core pedagogical techniques to help our students best connect with physics.

I enjoy interacting with undergraduate students both in and outside the classroom. My office hours would often go much beyond the stipulated hour as discussions intensified, taking precedence over merely solving a home-work problem. In recognition of my passion and contribution for teaching, I was conferred awards for excellence in teaching by both the student body, the Associated Students of Caltech (ASCIT) in 2018 and the R. Bruce Stewart Prize by the Caltech Physics Department in 2019.

I do not agree with the conventional wisdom that interesting topics in theoretical physics are beyond the reach of undergraduate students. I can envision teaching advanced classes, both formally and as informal reading courses, in topics such as general relativity and quantum computation. These topics are among the most exciting for young physicists, and I look forward to sharing them at a rigorous but approachable level. Physics is best learned hands-on, and an orthogonal perspective to a student's learning can be added by introducing some broad components of cutting-edge research in advanced courses. This way, students are able to connect what is being taught to how it applies to more exciting avenues beyond the textbook. In particular, since my research lies at the interface of quantum mechanics and gravity (details in the research statement) and focuses on the very fundamentals, this strategy often becomes accessible to me — something I implemented in the Advanced Quantum Mechanics course I was the teaching assistant for, where we designed problems and topics touching on quantum information and entanglement ideas as they applied to our work on Hilbert space factorizations.

I strongly believe in the importance of science outreach and popularization, something which reflects in my approach to teaching and research. As part of my efforts as Teaching Fellow, I led an initiative supported by the Center for Teaching, Learning, and Outreach (CTLO) at Caltech for which we recorded the sophomore/junior level course I taught in Fall 2019 on "Vibrations and Waves" and offered it as an online course available at http://waves.caltech.edu. In a rather unique online offering, course materials were made public in June 2020, creating an open-source learning resource, complete with recorded lectures, recitations, homework & exam problems, and their solutions to offer a self-teaching course to audiences beyond Caltech. It has been well received by diverse audiences, and we expect it to remain so and grow in the future. On a more broader note, I enjoy engaging in active outreach and intend to continue so, reaching out to more general audiences with the fascinations of science.

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3. Teaching Experience at Caltech

During my time as a graduate student at Caltech, I got a unique opportunity to engage in teaching at various different levels with a wide variety of instructional roles. I have served as a recitation instructor, head TA, Teaching Fellow, and a grading TA. The recitation structure at Caltech is very unique — unlike many other schools, where recitations only involve doing practice problems or discussing the homework, here at Caltech, you can get the chance to actually engage and be instrumental in full "lecture-style" classes. Below is a list of the various classes I was a part of, their descriptions, and the instructional roles I was engaged in:

Ph1 Sequence on Classical Mechanics and Electromagnetism

As a section instructor, I engaged in two/three recitations per week (two for Ph1a, three for Ph1b and Ph1c), one/two of which was a lecture-style recitation where I discussed the material and solved relevant examples in class. The other recitation in the week was a special "flipped section" where the students would break into small groups to work on a set of interesting and challenging problems, aided by informal interaction and brainstorming with me, to encourage collaboration, discussion, and the ability to think outside the box.

- **Ph-1a: Introduction to Classical Mechanics — Fall 2016**

Ph-1a is a required freshmen class for all majors, covering the basics of Newtonian mechanics, spanning kinematics, Newton's Laws, gravity, circular motion, energy-momentum, rotational motion, orbital dynamics, and fluid mechanics.
Text: *The Mechanical Universe: Mechanics and Heat*, by Frautschi et al.

- **Ph-1b Practical Track: Introduction to Electromagnetism —Winter 2016 & Winter 2017**

Ph1-b Practical is a freshmen level course for most non-physics majors, covering the basics of electricity, magnetism, and their practical application. Topics covered include electric fields and potential, Gauss' law, Ohm's law, circuits and components, and magnetic fields and forces.
Text: *Physics for Scientists and Engineers*, Vol. 2 by Serway & Jewett

- **Ph-1c Practical Track: Electromagnetism & Special Relativity — Spring 2017**

Ph1-c Practical is a freshmen level course for most non-physics majors, covering the basics of electromagnetism, and special relativity. Topics covered include magnetic materials, Faraday's laws, induction, AC circuits, EM waves, interference, special relativity (time dilation, length contraction, simultaneity), and the Hall effect.
Text: *Physics for Scientists and Engineers*, Vol. 2 by Serway & Jewett

Ph2 Sequence on Waves, Quantum Mechanics, and Statistical Physics

As a section instructor, I engaged in two recitations per week, which were lecture-style classes where I discussed the material in detail, solved relevant examples in class, and went on interesting tangents and applications. For Ph-2a and Ph-2b, I also served as the head TA, managing course logistics and making sure course ran smoothly by being a point of contact between students, instructors, and the TAs.

- **Ph-2a: Vibrations & Waves — Fall 2017, Fall 2018, Fall 2019**

Ph-2a is a sophomore/junior level course for most non-physics majors, covering the basics of oscillatory systems, and their practical applications. Topics covered include simple harmonic motion, damped/forced and coupled oscillations, wave propagation, normal modes, Fourier decomposition, standing waves, interference, polarization, and dispersion. The 2019 version we taught is now available as an online class for public consumption at http://www.waves.caltech.edu
Text: *Vibrations and Waves,* by George King

- **Ph-2b: Introduction to Quantum Mechanics — Winter 2018 & Winter 2020**

Ph-2b is a sophomore/junior level course for most non-physics majors, covering the basics of quantum mechanics, and some practical applications. Topics covered included the Schrödinger equation and its solutions in 1D potentials, Born rule, Hilbert space, bra-ket notation, spin systems, hydrogen atom, angular momentum, and basics of quantum statistical physics.
Text: *Introduction to Quantum Mechanics,* by David Griffiths

- **Ph-2c: Statistical Physics & Thermodynamics — Spring 2018**

Ph-2c is a sophomore/junior level course for most non-physics majors, covering the basics of ensembles and statistical systems, thermodynamic laws, applications in energy technology and other areas.
Text: *Thermal Physics,* by Kittel & Kroemer

Other Courses

- **Ph-12a: Advanced Vibrations & Waves — Fall 2015**

I was a grading TA, grading homework and exam problems for this class, which is a sophomore/junior level class, the equivalent of Ph-2a for physics majors.
Text: *The Physics of Waves,* by Howard Georgi

- **Ph-125c: Advanced Quantum Mechanics — Spring 2017**

Ph-125c is a "topics" class in quantum mechanics targeted at senior undergrads majoring in physics, and graduate students. Topics covered included entanglement, EPR, density matrices, measurements, quantum channels, decoherence, interpretations of quantum mechanics, introduction to quantum computing and quantum field theory.
Text: *Professor's lecture notes, and assortment of textbooks for references*

4. Evidence of Teaching Effectiveness

To present evidence of my teaching effectiveness, this section presents an abridged version of my student evaluations from the various classes I have taught and been a teaching assistant for at Caltech during 2016 - 2020. A full, unabridged version of student feedback is available in Appendix-A.

All responses are from Caltech's Teaching Quality Feedback Reports (TQFRs) that are filled out by students at the end of each course, voluntarily and responses are kept anonymous. All quantitative ratings are on a scale of 5.

4.1 Formal Student Evaluations (Quantitative)

The following table lays out my quantitative response by students on a scale of 1 - 5 (with 5 being the highest, most favorable score) on the prompt "Overall Teaching Effectiveness." Other prompts and their responses which are included in the TQFR survey can be found in the unabridged Student Evaluations in Appendix - A. I have listed all courses I was an instructor/TA for, save one class: Ph12a where I was a grading TA in my first term at Caltech, and there were not enough responses in the TQFR to be statistically meaningful.

(All scores are on a scale of 1 - 5, with 5 being the highest, most favorable score)

Course	Term taught	Mean Rating	Department Mean	Caltech Mean
Ph1a	Fall 2016	4.92	4.45	4.42
Ph1b Practical Track	Winter 2016	5.00	4.55	4.38
Ph1b Practical Track	Winter 2017	4.93	4.43	4.43
Ph1c Practical Track	Spring 2016	4.83	4.49	4.37
Ph2a	Fall 2017	4.90	4.51	4.41
Ph2a	Fall 2018	4.95	4.28	4.41
Ph2a	Fall 2019	4.71	4.49	4.52
Ph2b	Winter 2018	4.82	4.50	4.46
Ph2b	Winter 2020	4.93	4.42	4.53
Ph2c	Spring 2018	4.94	4.50	4.47
Ph125c	Spring 2017	4.88	4.18	4.42

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4.2 Select Student Reviews

- Ashmeet is truly a blessing. His recitations were the perfect mix of extremely relevant derivations/etc and tangents (which were often also very helpful in either the calculations or the intuition). Ashmeet really focused on the intuition and thought-processes behind everything (which was fantastic in getting a feel for these pretty difficult ideas) but never lost focus on the nitty-gritty. He embodies everything good about Physics.

- Thank you so much for putting so much effort into your recitation. I learned SO much and am that much more confident in my physics ability now. I've started liking physics much more now thanks to your recitation and way of explaining things. I've gained another foundational layer and want to now go back in time and take physics analytical freshman. Thank you for making this a great class and inspiring students like to continue taking physics!

- Ashmeet is a blessing upon this Earth. Best TA I've ever had.

- Ashmeet is perhaps the best TA I have had so far and clearly has a deep understanding of what he is teaching and knows how to explain it clearly and simply.

- Honestly, Ashmeet is a god and carries the course. Give this man a medal.

- Ashmeet is absolutely great, he carried me through this course! Provides great comments and answers to all the questions in a way that makes you think and get to the answer yourself, thus understanding the concepts behind the questions very well. He is also very helpful and always available outside of class/ Office Hours, sending additional information and ready to meet to explain anything that is needed to be explained.

- Ashmeet is the best TA ever. His recitations are amazing, and I always enjoy attending them. He is clear and he does an amazing job of connecting concepts together and illuminating subtle insights. He displays concern for our learning and does an amazing job of making physics interesting and accessible.

- Best TA I've ever had. Knew the material inside and out, could answer any question, gave helpful hints. He was one of the few people who taught me the material.

- Ashmeet wrote very challenging problems, but they were interesting and rewarding to solve. When approached outside of class and office hours, he was extremely eager to help me understand both class material and homework. I'm very glad he was a TA for this class.

- I switched into Ashmeet's section because Ashmeet is great! He really knows what he's talking about, is incredibly quick with the chalk, and is very happy to help. He explains confusing concepts well, and explains "old" concepts (perhaps ones you thought you knew well) using different phrases that make you think about them in new ways. He makes you see how everything is related.

- Ashmeet is the greatest TA ever. Everything he presents in recitation really changes my perspective on physics. I still haven't forgotten the first recitation he held; it made me

appreciate physics more! He's also very helpful and clear in his information, and he really understands physics on a spiritual level. 10/10 would recommend Ashmeet. His flipped sections were also pretty fun! I wish that I had gone to more of them because they really help with the quizzes too!

- Ashmeet is perhaps the greatest TA I've ever seen. From the very beginning, even with the simplest concepts of charge and electric force, he explained things in such a way that I left recitation with a deeper, more fundamental understanding of E&M.; And no matter the concept, he was always ready to help and explain further why things mattered, what the equations really meant, how to apply and connect concepts, etc. Ashmeet is an excellent TA and I really hope I'll get to have him as a TA next term.

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5. Educational Leadership and Classroom Innovation

5.1 Physics Teaching Fellow at Caltech

The Physics Department at Caltech, in addition to my classroom teaching role, also appointed me as Physics Teaching Fellow for the 2019-2020 academic year. My focus as Teaching Fellow was to serve as a resource for TAs, working with them at the grass-root level to evolve and better integrate the existing teaching setup. A few examples of my work as Teaching Fellow are outlined here:

- I led a discussion with the incoming physics graduate class on the “Joys of Teaching,” sharing the structure of teaching and TAing in the Department, give an overview to effective teaching practices, tips and tricks and lay out the resources available for TAs.

- Organized a TA workshop on “flipped sections,” an active learning technique where students work in small groups on interesting problems, aided with informal discussion with the TA.

- Organized and led “micro-teaching” practice sessions for TAs to give them feedback on their teaching style, presentation, and organization.

- Compiled a “Welcome TA” document to serve as a starting point, and a go-to resource for TAs. It included ideas, lessons, and thoughts I had gathered and discussed over my years of teaching at Caltech for effective TAing — spanning tips for engaging effective recitation, office hours, and good grading practices. This Welcome TA packet can be found in Appendix-B.

- Led an effort to introduce Gradescope (http://www.gradescope.com), an online grading portal to Caltech courses in 2019, which was then successfully adopted by many classes. To support this effort, I also organized a workshop on effective grading practices, and how to implement them with Gradescope.

- Worked with TAs on an individual basis, discussing course-specific details and strategies, and also sitting in to observe their recitations to provide feedback from the "student's perspective."

- Worked with the Caltech Physics Department and the Center for Teaching, Learning, and Outreach (CTLO) to develop and implement a midterm course feedback survey to help faculty and TAs get specific and useful feedback for their classes.

5.2 Online Physics Course on "Vibrations and Waves"

In collaboration with the Caltech Physics Department, and the Center for Teaching, Learning, and Outreach (CTLO) at Caltech, and following positive feedback from students, we released an online version of the sophomore/junior physics class on "Vibrations & Waves" I taught with Prof. Frank Porter during Fall 2019. The class is available at:

http://www.waves.caltech.edu

The class deals with keystone concepts of oscillatory behavior in physical systems (such as Simple Harmonic Motion, Normal Modes, Wave Propagation, Fourier Decompositions, Interference, Diffraction, and Polarization) which forms a core foundation in understanding various physical phenomenon. The class is aimed at non-physics majors with a pre-requisite of basic calculus and introductory mechanics, making it accessible to a wide audience. The course balances theory and applications, and covers mathematical as well as heuristic aspects. The course offers many live demonstrations conducted in class which lets the audience see the principles being taught in action, which is a crucial aspect of physics education. We also go on various interesting tangents in the course on how ideas in Vibrations & Waves connect with real-world applications.

In a rather unique offering, course material was made public in June 2020, creating an open-source learning resource, complete with recorded lectures, recitations, homework & exam problems, and their solutions to offer a self-teaching course to audiences beyond Caltech. In the first six months of its release, it has been well received by diverse audiences, and we expect it to remain so and grow in the future.

This effort to release the course publicly was funded through the Caltech Innovation in Education Fund Award for which I was the co-principle investigator with Prof. Frank Porter.

5.3 Curriculum Development/Classroom Innovation

During my time as an instructor and teaching assistant at Caltech, I strived to implement newer, more engaging teaching techniques in the classroom:

- Implemented a "flipped section" format for the Ph1abc sequence spanning introductory classical mechanics, electromagnetism, and special relativity. In this format, in addition to the usual lectures and recitations, the students would interactively brainstorm on challenging

problems, aided by informal interaction with TAs to encourage collaboration, discussion, and the ability to think outside the box.

- Implemented simple demonstrations in class to reinforce the learning outcomes of the material being discussed, such as measuring the storage capacity of a DVD disk by studying a laser's diffraction pattern through it, or measuring the speed of light by studying nodes in a melting chocolate bar in a microwave.

- Worked in collaboration with Prof. Frank Porter to redesign and implement a more "learning-focused" grading system for Ph2a: Vibrations & Waves. The homeworks were much more heavily weighed than the exams to encourage learning, albeit with a stronger emphasis on how students worked out the details of a problem instead of just getting to the final answer. The exams were also given a collaborative component. While the initial reviews of this new format were mixed, we hope to continue improving upon it.

- Initiated a discussion with faculty on looking into more broader structural changes to our larger undergraduate courses so as to make them more amenable to the learning needs of students.

5.4 Selection Committee of the Richard P. Feynman Teaching Prize

I was invited, and served on the selection committee — representing the graduate student body — for the 2020 edition of Caltech's Richard P. Feynman Prize for Excellence in Teaching. The award, which was established in 1993, is to honor annually a Caltech professor who demonstrates, in the broadest sense, unusual ability, creativity, and innovation in undergraduate and graduate classroom or laboratory teaching. All tenure-track and tenured professorial faculty of the Institute are eligible, and nominations for the Feynman Teaching Prize are welcome from faculty, students, postdoctoral scholars, staff, and alumni.

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6. Honors, Awards, and Recognition

During my teaching experience at Caltech, I was awarded the following four prizes and awards for my work in the classroom and beyond:

6.1 Associated Students of California Institute of Technology (ASCIT)'s Award for Excellence in Teaching 2018

The ASCIT Award for Excellence in Teaching is awarded to 4 professors and 4 teaching assistants each year across all academic disciplines at Caltech, and I was conferred this award for the 2017-2018 academic year. The award is exclusively managed by the student body, including both the nomination and selection process. The awardees are honored at a special banquet ceremony with a citation, and the students who nominated the awardees share their experiences with those in attendance.

6.2 R. Bruce Stewart Prize for Excellence in Teaching 2019

The Stewart Prize is to be awarded to a graduate student teaching assistant who demonstrates, in the broadest sense, unusual ability, creativity, and innovation in undergraduate/graduate classroom or laboratory teaching of physics. The Department of Physics at Caltech administers this prize which was awarded to me for the 2018-2019 academic year. Nominations for the Stewart Prize may be made by any member of the Caltech community, including faculty, students, postdoctoral scholars, alumni, and staff. The awardee is conferred with a certificate and a $4000 cash prize at a special awards ceremony hosted by the department.

6.3 Caltech Innovation in Education Fund Award 2020

The Center for Teaching, Learning, and Outreach (CTLO) at Caltech awarded the Innovation in Education Fund Award in February 2020 to Prof. Frank Porter and me for supporting the release of our online course on "Vibrations & Waves" (http://www.waves.caltech.edu). The Caltech Innovation in Education Fund is designed to support Caltech faculty developing new courses, implementing innovative and evidence-based teaching methods, upgrading educational facilities, or pursuing other new academic activities.

6.4 Dean's List of Outstanding TAs

The Dean's Office at Caltech recognized me as an Outstanding TA for Fall 2019 based on student evaluations for my teaching of the sophomore/junior physics course on Vibrations & Waves. The recognition came along with a $20 Amazon gift card.

7. Sample Syllabus & Course Materials

The following is a syllabus of a sophomore/junior level class on the physics of vibrations and waves intended for non-physics majors. The template is based on the class I taught at Caltech, though it has been further and substantially modified. While the topic of the class is a rather "standard" topic in physics instruction, the learning-centric assessment, and the breadth and richness of topics should be noted. In addition, guidelines for students to be effective problem solvers is an integral part of this course, and appropriate resources are provided to reflect this. Part of this template was developed in collaboration with Prof. Frank Porter of Caltech with whom I co-taught the class.

Ph-2a: Vibrations and Waves

Instructor: Ashmeet Singh

Lectures: Tuesday and Thursday (11:00 am - 12:00 pm)
Recitation 1: Wednesday (1:00 pm - 2:00 pm)
Recitation 2 (Flipped Section): Friday (1:00 pm - 2:00 pm)

Instructor Contact Information:
Email: ashmeet@caltech.edu
Extension: *ext*
Office: *office location*
Email is usually the fastest, most reliable way of reaching me, I put high priority on email from students! I'll be happy to arrange an in-person meeting as desired.

Recitation TAs: *Names of TAs, email, office hours, office address*

Graders: *Names of TAs, office hours, email, office address*

Course Motivation & Overview
Vibrations and waves are commonplace in our physical world – whether it be in gas, liquid, or solid, things vibrate, and waves propagate, carrying energy and information. We even have waves in a vacuum; that is how the light from the sun can reach us and power our world. They form the very reason why our world is so dynamic and exciting. There is much commonality in the corresponding descriptions of processes at many scales. So whether it be ideas in quantum mechanics of the subatomic realm, or electrical circuits and machines around you, or powerful astrophysical phenomena like gravitational waves, an understanding of the somewhat abstract notions of a wave or a vibration provides a key foundation for understanding the very heart-and-soul of how Nature works.

This is an introductory course on the generic properties of vibrations and waves, including both discrete and continuous media, with application across a broad range of phenomena and fields. Lecture demonstrations are used to introduce and develop the concepts. Abstractions and concrete examples are discussed.

Prerequisites: Ph1a (Introduction to Classical Mechanics), Ph1b (Introduction to Electromagnetism), Ph1c (Electromagnetism and Special Relativity)

Course website: *website link*

Online help forum: Piazza, you will be enrolled on the class Piazza automatically. You will be able to ask (anonymously) questions about something you don't understand, including about homework problems. Your colleagues in the course are encouraged to post responses, and the instructor and TAs will also see the discussion and post what they hope will be helpful comments.

Learning Outcomes

- Explain oscillatory and wave phenomena including resonance, damping, normal modes, superposition, interference, diffraction, dispersion, phase velocity and group velocity.
- Understand that many phenomena may be described at least approximately within the general framework of simple harmonic motion
- Apply your understanding to problems of mechanical motion and electronic currents
- Apply Taylor series expansion to approximately describe additional phenomena as simple oscillations
- Learn about Fourier decompositions and their applicability to a variety of physical and mathematical setups

Textbook: Vibrations and Waves, by George King
We will follow roughly one chapter per week of the textbook, with additional interesting topics discussed in the lectures

Lecture/Recitation Organization

We believe learning is best done by engaging with the material at multiple levels – from abstract math to practical demonstrations. With this in mind, the class is organized into "lectures": where we introduce broad concepts, developed using basic examples and lots of in-class demonstrations to show you the physics live-in-action. The other aspect of our teaching is "recitations", holistically intertwined with the lectures, where we explore ideas in further depth, look at various examples and subtleties, and talk about interesting applications along the way. There will be two lectures and two recitations each week. One of these recitations will be a "Flipped section" designed to improve problem-solving skills where different groups would collaboratively work on the chalkboard with informal interaction with the TAs.

Assessment and Evaluation

The grades of this course will be determined on the basis of weekly assignments, a mid-term "exam," a final exam, and a short presentation towards the end of the term. Under the theory that you learn best by doing, the problem sets will be heavily weighted. The plan is to compute grades based on:

1. Weekly Assignments : 50%
2. Mid-term during flipped section: 10%
3. Final Presentation :10%
4. Final Exam : 30%

In the hopes that it will be a bit more fun and motivating, we will deviate somewhat from the traditional sequence of quizzes and exam as well. In place of a formal "midterm exam," we will assign a special homework set with the following twist: you will work on it during a flipped section recitation, immediately following which (while in class itself) you will write your solutions to turn them in. The final will be divided up into a regular exam, and a group presentation (details and topics to be decided later).

Assignment, Exam, and Collaboration Policies
Assignments are due on Tuesdays at 11:00 am right before lecture.
Late policy: You must contact the instructor or TA if you need extra time to complete the work.

Collaboration is encouraged and reflects the real-life problem-solving experience. A good practice is to first give problems a good try by yourself. Then maybe you will have the satisfaction of explaining it to your colleague. However, whatever you turn in should be what you think you understand. Imagine someone asking you to explain it. If you use some resource on the web for a problem, reference it!

COURSE SCHEDULE

Week 1: Why Vibrations & Waves Matter; Simple Harmonic Motion
References: Chapter 1 from King
Topics: Motivation for Vibrations and Waves: Ubiquity of Simple Harmonic Motion; Concept of Equilibrium and Taylor Expansions; Examples of Simple Harmonic Motion: Vibration of a Diatomic Molecule, Springs in Combination; Energy of Simple Harmonic Motion; Oscillations in Multiple Dimensions & Lissajous figures

Week 2: Damped Harmonic Motion
References: Chapter 2 from King
Topics: Viscous damping; Formal solutions to the damped harmonic equation; Different regimes of damped motion, Further analysis of critical and over-damped cases; Energy of the Damped Oscillator; Quality factor; Introduction to Forced Harmonic Motion. Solving an in-homogenous ordinary differential equation

Week 3: Forced Harmonic Motion
References: Chapter 3 from King
Also, brush up on basics of electrical circuits from Ph1b by reading relevant chapters of Physics for Scientists and Engineers, Vol. 2 by Serway & Jewett
Topics: Frequency response of oscillator in both amplitude and phase; Resonance; Transient and Steady solutions. The Mexico City earthquake, Tacoma bridge collapse and wind vortices, Seismic Isolation Stack; Resonance on the Road; Electrical RLC Circuits

Week 4: Coupled Oscillations
References: Chapter 4 from King
Topics: Motivation for decoupling N-coupled oscillators; Normal Modes and Normal Coordinates; General Solutions, Vibrational Modes of Carbon Dioxide and Global Warming; RLC Circuits; Analysis of Forced, Coupled Oscillators

Week 5: Wave Propagation
References: Chapter 5 from King
Topics: Continuum Limit and "The" Wave Equation; Plane Wave Solutions and Examples; Reflection, Transmission and Impedance; Impedance Matching and the Conical Shape of Megaphones

Week 6: Normal Modes & Fourier Analysis
References: Chapter 5, 6 from King, lecture notes (to be posted)
Topics: Normal Modes of a Continuum System; Boundary Conditions (fix-fix and fix-open); Standing Waves; General Solutions; Standing Waves and Melting a Chocolate Bar in a Microwave, Fourier Series: Example and Connections; Basel Problem and the Guitar String; Can we hear the Shape of a Drum? Normal Mode Solutions of the Schrödinger Wave Equation in 2D; Separation of Variables

Week 7: Interference
References: Chapter 7 of King, lecture notes (to be posted)
Topics: Young's Double Slit Experiment: Far-field limit, Wavefronts, Intensity patterns; Sound channels in the Ocean and Atmosphere. Tales from World War - II to rescue pilots; the Roswell Conspiracy, Flying Saucers and Project Mogul, Interference due to Reflection and Phase Shifts; Newton's Rings; Light Detection and Ranging (LIDAR)

Week 8: Polarization & Dispersion
References: Chapter 7 of King, lecture notes (to be posted)
Topics: The Basic Idea; Different Polarizations; Polarizers and the Malus Law; Waveplates and basics of Birefringence; Jones Matrix; Dispersive media; Superposition; Group and Phase Velocities; Dispersion through a Prism; Dispersion in Diamond and Cubic Zircona

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Week 9: Wrapping Up

References: Lecture notes (to be posted)

Topics: The Principle of Least Action; Fourier Decompositions, Conjugate Variables and Heisenberg's Uncertainty Principle, Measuring the storage capacity of a DVD by shining a laser on it; Wrap-up; Illustrative examples on Coupled Oscillations, Fourier Decompositions and Boundary Conditions, Interference, Final Review

A Note on Problem Solving for Ph-2a

A goal for this course is to help you to become a better problem-solver. The graders will look for "good" solutions that have characteristics along the lines illustrated in the example here. You may lose points even if you get the "right" answer if it is not clear, if you haven't stated assumptions clearly, or if you have not demonstrated a logical approach.

1. Don't rush to the text for "The Formula". You'll learn much more if you do some thinking for yourself.

2. Draw a picture! This helps to collect your thoughts and make sure you understand the problem.

3. Try to develop some intuition for how you think the system will behave, or for what the answer ought to be. You may discover that you are wrong, but it can help to guide your approach, and you can modify your thinking as you go along.

4. Define relevant quantities. Before writing down numbers, define some symbols, which will help you keep track of what you mean. It also means you will have derived something more generally useful.

5. Give some thought to your choice of symbols. In may cases, you'll just use whatever we use in lecture and the book. But try to choose symbols that are meaningful to you and not a source of confusion.

6. You will likely want/need to set up a coordinate system. Try to choose something that makes the problem look "simple". This might mean using an angle rather than a cartesian axis, for example. Symmetries can often be taken advantage of. Choose the origin for simplicity if you can.

7. Think about and state assumptions that you think are implicit in the problem statement. We won't necessarily state all of these when giving the problem. This reflects real-world problems, where part of understanding and attacking a problem is to identify what the problem is.

8. Finally, make sure the units are sensible. If one side of an equation evaluates to a length, the other should as well. It is remarkable how often people neglect this simple sanity check!

Now let's consider attacking a sample homework problem:

Problem: Given a 1 kg mass on a spring, with spring constant k = 1 N/m, what is the natural frequency of oscillation?

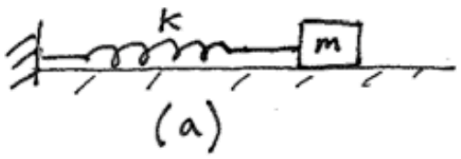
Here are two attempts at a solution:

The solution that makes your instructor very sad:

$$\sqrt{1/1} = 1\ \mathrm{s}^{-1}$$

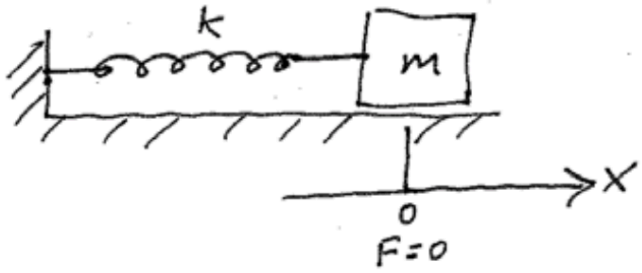
Comments: I expect the grader to seriously ding you if you turn in a solution such as this, even if the answer is nominally "correct". You have not explained what you are doing. The problem statement here is quite vague, and you have not said what assumptions you are making. Have you thought about whether the problem is horizontal or a mass hanging from a spring under gravity? You have not been very clear about what you are calculating. You give units of s^{-1}, but since we are talking about frequency, do you mean Hz? Or is it radians/s?

The gold star solution:
Hmm, this is pretty vague, what does it mean? Is it a horizontal spring, like picture (a), or a vertical one, like picture (b)? In either case, I'll assume we are on the Hooke's law region of the spring, since that is implicit in asking for the natural frequency.



Fortunately, the natural frequency will be the same either way, since only the equilibrium length of the spring is altered between these two possibilities. I'll go with (a) to keep it simple. I'm also going to assume that the mass slides without friction, since this is implicit in finding the natural frequency. I'll also assume the spring is massless, since we don't have any further information about it.

Now let x be the horizontal coordinate along the direction of motion, with origin at the equilibrium position:



We have a restoring force on the mass of $-kx$, or $F = ma = -kx$, where $a = d^2x/dt^2$ is the acceleration. Thus, the differential equation of motion is:

$$m\frac{d^2x}{dt^2} = -kx$$

The general solution may be written in the form,

$$x(t) = A\sin\sqrt{\frac{k}{m}}t + B\cos\sqrt{\frac{k}{m}}t$$

where A and B are constants of integration that we won't need to worry about here, since they don't affect the oscillation frequency. A full oscillation of the system thus occurs when $\sqrt{k/m}t = 2\pi$. That is, the period of oscillation is $T = 2\pi/\sqrt{k/m}$, and hence the natural frequency of the oscillator is:

$$f = 1/T = \sqrt{k/m}/(2\pi) = \frac{1}{2\pi}\sqrt{\frac{1\ \mathrm{N/m}}{1\ \mathrm{kg}}} = 0.159\ \mathrm{Hz}\ .$$

Alternatively, the natural frequency can be expressed as $\omega = 2\pi f = 1\ \mathrm{rad/s}$.

Comment: I have chosen one particular path to solution here, many other paths are also fine, as long as your solution is clearly developed.

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8. List of References

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Appendix - A: Complete Student Evaluations

The following is an unedited compilation of Ashmeet's student reviews spanning courses taught between 2016-2020. They have been taken directly, and in full from Caltech's "Teaching Quality Feedback Reports," and represent unfiltered student responses filled out at the end of each course, voluntarily and responses are kept anonymous. All numeric scores are on a scale of 5. They are arranged by course, in reverse chronological order.

Ph2b: Introduction to Quantum Mechanics, Winter 2020

(quantitative responses from 14 students, section enrollment of about 20 students, total class size of 60)

	Score	Dept.	Div.	Caltech
Provided helpful comments on assignments, papers, exams	**4.90** ± 0.30	4.55	4.50	4.56
Answered questions clearly and concisely	**4.85** ± 0.53	4.50	4.48	4.54
Was well prepared for section, office hours or lab	**4.92** ± 0.27	4.59	4.53	4.57
Presented material clearly in section or lab	**4.93** ± 0.26	4.52	4.53	4.60
Overall teaching effectiveness	**4.93** ± 0.26	4.42	4.41	4.53

Amazing TA. Clearly cares about the students and explains concepts wonderfully.
Honestly one of the best TAs you could ever have. He's prompt with emails, holds very good recitations, and genuinely excites students about physics. We need one of him for every subject!
Really enthusiastic and presented good material during recitation. Consider making recitation more organized though and linear.
Congrats on graduating! You will be missed and I wish you the best in your future endeavors.
So kind, helpful, and wanting to make sure I succeeded. Ashmeet goes above and beyond with TAing, and I will miss him a lot next term.
Ashmeet is not only an excellent instructor and beyond friendly person, he's inspirational. Hearing him talk about the topics and concepts with excitement trickled down to me and made me want to keep learning.
Fantastic instructor, really good at explaining the concepts. Gonna miss him!
Ah Ashmeet, it's too bad this is your last class you would TA. It was an honor and pleasure being in your class. You're a wonderful teacher and you should be very proud of it. The students love you!
Ashmeet is a great TA! He really took the time to draw out the important concepts from lectures and make sure we really understood them. I really liked how he'd go through examples in rec and make us think about the questions. We'll miss you, Ashmeet!
Really good TA! really good examples and tries to explain everything.

Ashmeet is a great TA! He really took the time to draw out the important concepts from lectures and make sure we really understood them. I really liked how he'd go through examples in rec and make us think about the questions. We'll miss you, Ashmeet!
Really good TA! really good examples and tries to explain everything.
I only went to two of his sections, but the times that I did go, he was very animated in his explanations of the math behind the physics, and also about sharing his own work. I have seen him help people in Downs outside of class, and it is very heartening to see!
Probably the best class I've taken at Caltech, and I am a CS major. Cheung's lectures literally flow like water, and each concept just naturally links into the other. Ashmeet is also probably the best TA of all time, and you build such good intuition at his recs that you feel like a master physicist. Again, I am not even that interest in physics. …

Ph2a: Vibrations and Waves, Fall 2019

(quantitative responses from 38 students, section enrollment of about 50 students, total class size of 117)

	Score	Dept.	Div.	Caltech
Provided helpful comments on assignments, papers, exams	**4.78** ± 0.78	4.48	4.38	4.47
Answered questions clearly and concisely	**4.82** ± 0.68	4.48	4.41	4.49
Was well prepared for section, office hours or lab	**4.87** ± 0.66	4.55	4.47	4.57
Presented material clearly in section or lab	**4.82** ± 0.68	4.49	4.45	4.55
Overall teaching effectiveness	**4.71** ± 0.76	4.49	4.42	4.52

really smart guy who stresses the importance of understanding the fundamental concepts on the physics but is also really good and helping people answer and understand homework questions
He's very dedicated and good at answering questions! Amazing TA.
Very good pacing and clearly explains topics. Especially like the algebraic explanation of deriving equations and the intuitive notion behind it.
Ashmeet is the only reason I didn't drop this class. I had huge issue with the organization, lack of relevant texts, and difficulty of the homeworks. Ashmeet was always willing to help me learn something and frequently went out of his way for me and other students.
Was very helpful at office hours. Very open to feedback and acted on it; recitation sections got better--keep them at a slower pace, end on time--try not to cover and race through a bunch of stuff just choose the most important topics.
a blessing- always willing to go above and beyond to help students
Did a great job of being available for students. I really enjoyed his passion for physics, it got me excited about it (which is not a particularly easy task since I'm not the hugest fan of physics). Sometimes recs were a little hard to follow (got better as time went on though and I felt like my understanding slowly increased by the end). Overall, enjoyed him as a TA.

Ashmeet is a GODSEND. He always stays extra late during office hours to make sure no one has any questions by the time he leaves; he's sometimes still around 1-2 hours after his office hours should've ended. His recitation sections helped tremendously with the homeworks. This isn't to say that he gave us answers and it made the class easy; he basically went through examples and concepts relevant to homework very often and made sure everyone understood what he was doing. Attending his recitation and office hours was basically essential for many of the students, I felt like, to doing well in the course. His recitation was more helpful than the actual lectures most of the time.
So so great. Always stayed after OH to continue answering questions and spent time with me individually to go over a concept I didn't understand. I'm so glad to have had him.
Thanks for all the help at office hours. It definitely helped a lot.
Such a good TA! Amazing at explaining concepts
Amazing instruction. I learned more and now understand more about physics because your recitation than I have in any course at Caltech thus far.
great recitations! sometimes they would vary in level of difficulty, and i would have appreciated more example problems during recitations.
Thank you so much for putting so much effort into your recitation. I learned SO much and am that much more confident in my physics ability now. I've started liking physics much more now thanks to your recitation and way of explaining things. I've gained another foundational layer and want to now go back in time and take physics analytical freshman. Thank you for making this a great class and inspiring students like to continue taking physics!
Ashmeet is an amazing TA and gives great examples and reasoning for derivations! He made jokes in recitation, provided interesting real-world examples, and was always happy to stay after class to answer questions. He is one of the best TAs I have had at Caltech!
Recitation sections were very helpful! Came to rec more often than lectures to learn the course
Fantastic TA, honestly my favorite! Actually helped me understand Waves and Oscillation on a more fundamental and theoretical level.
The best TA I've had. Recitations were clear and interesting (more useful than going to lecture). He always tried to get us to understand the theory and reasoning behind a problem, rather than giving direct help.
Ashmeet was extremely excited about the course and his section was entertaining to go to. His office hours were beyond helpful, as they were sometimes borderline necessary to complete the set. Probably the only reason this class was possible to do well in.
His office hours were helpful, given the difficulty of the sets. However, I think it is important to note that he tends to emphasize "intuition" when approaching a problem which is very discouraging to someone who may not understand a problem.
Amazing TA. Truly cares about the students and their understanding beyond just knowing when and how to use a formula. His recitation sections were great and really helpful. I enjoyed how he mixed the in-depth explanation of the material with practical examples so we keep track of the big picture as well as the details. An example for what teaching would be ideally.
Thank you for explaining concepts so clearly and in a very engaging way! I really had fun in this class and learned so much more because of recitation. This was the first physics class at Caltech that I truly looked forward to attending each week.
Absolutely excellent; the saving grace of the class.

One of the best classes I've taken at Caltech, but that is primarily due to the head TA, Ashmeet. Ashmeet is the GOAT, so if he is still TAing, then definitely take this class since he explains everything so clearly, and is clearly passionate about the topic, enough to make you like the material even if you don't. Overall, the class flows really nicely and the topics build off of each other. Homework isn't that hard (although not that easy either). The midterm and final have this weird structure where you can work in groups for half of it; it's a hit or miss depending on who you work with.
shout-out to TA Ashmeet, who has been single-handedly carrying me through physics since Ph1a
Ashmeet was a fantastic TA. I found that lecture was not very well taught, but Ashmeet definitely covered everything we needed in recitation, and he was always extremely helpful. Ashmeet basically taught me Ph 2a
Interesting class that goes over a lot of cool concepts, but make sure you do well on the homework assignments if they are to keep the 70% weight for next year. Ashmeet is a god-tier TA; you're better off just going to his recitation and reading the lecture notes online instead. Side note, if you are taking this with Ma2 Prac versus Anal, you'll probably have a rougher time since the mathematical concepts don't line up one-to-one in the order they are introduced.
This class was fine. Lectures were kind of confusing and not helpful, but Ashmeet's section was amazing. I feel comfortable taking 2b next term because I know that he will be TAing it again. I always attended his section because they were pretty much a replacement for the lectures. If you are in his section then this class is completely doable. The sets were a little rough most weeks but OH was helpful and usually I was able to figure things out. Basically if you are in this class, go to Ashmeet's section and you will learn the material.
Ashmeet was a really good TA. I used his recs to actually learn the material. The lectures are very confusing but are sometimes helpful when the homework problems refer back to demos in the lecture. Even though I am a CS major, I learned a lot and the weight distribution of hw, midterm, and final is pretty nice.
Ashmeet is the hero that we desperately need, yet don't deserve. Really great course that gives you a great fundamental understanding of the material. Strongly recommend!

Ph2a: Vibrations and Waves, Fall 2018

(quantitative responses from 19 students, section enrollment of about 30 students, total class size of 77)

	Score	Dept.	Div.	Caltech
Provided helpful comments on assignments, papers, exams	**4.81** ± 0.53	4.28	4.24	4.40
Answered questions clearly and concisely	**4.90** ± 0.44	4.28	4.23	4.41
Was well prepared for section, office hours or lab	**5.00** ± 0.00	4.37	4.37	4.45
Presented material clearly in section or lab	**4.95** ± 0.22	4.29	4.30	4.46
Overall teaching effectiveness	**4.95** ± 0.22	4.28	4.26	4.41

Ashmeet is truly a blessing. His recitations were the perfect mix of extremely relevant derivations/etc and tangents (which were often also very helpful in either the calculations or the intuition). Ashmeet really focused on the intuition and thought-processes behind everything (which was fantastic in getting a feel for these pretty difficult ideas) but never lost focus on the nitty-gritty. He embodies everything good about Physics.
Thank you so much for explaining the material in way that makes sense during recs and office hours! I thought your recs were really engaging. I found myself paying attention the whole hour (which is something I have trouble doing in many classes). As a result, I feel that I got more understanding out of this class than any previous physics classes I've taken.
Thank you for a great term!
Ashmeet was overall very enthusiastic about teaching, which made a difficult subject much more approachable. He was great at explaining concepts and always had interesting examples.
Ashmeet is a blessing upon this Earth. Best TA I've ever had.
Fantastic TA! His sections were super engaging and interesting, and his office hours were super helpful for the problem sets.
Ashmeet is perhaps the best TA I have had so far and clearly has a deep understanding of what he is teaching and knows how to explain it clearly and simply.
You are the best TA ever.
Ashmeet is an incredible TA!! His office hours clarify all the concepts, and his example problems provide students with a bit more practice. Additionally, he is very open to answering questions outside of class.

Ph2c: Statistical Mechanics and Thermodynamics, Spring 2018

(quantitative responses from 16 students, section enrollment of about 35 students, total class size of 96)

	Score	Dept.	Div.	Caltech
Provided helpful comments on assignments, papers, exams	**5.00** ± 0.00	4.53	4.34	4.48
Answered questions clearly and concisely	**4.94** ± 0.24	4.45	4.36	4.47
Was well prepared for section, office hours or lab	**4.94** ± 0.24	4.54	4.38	4.51
Presented material clearly in section or lab	**4.94** ± 0.24	4.51	4.40	4.52
Overall teaching effectiveness	**4.94** ± 0.24	4.50	4.35	4.47

Honestly, Ashmeet is a god and carries the course. Give this man a medal.
Greatest physics TA
Ashmeet is absolutely great, he carried me through this course! Provides great comments and answers to all the questions in a way that makes you think and get to the answer yourself, thus understanding the concepts behind the questions very well. He is also very helpful and always available outside of class/ Office Hours, sending additional information and ready to meet to explain anything that is needed to be explained.
Best TA, can't ask for much more in a TA.

Ashmeet is the best TA ever. His recitations are amazing, and I always enjoy attending them. He is clear and he does an amazing job of connecting concepts together and illuminating subtle insights. He displays concern for our learning and does an amazing job of making physics interesting and accessible.

Ph2b: Introduction to Quantum Mechanics, Winter 2018

(quantitative responses from 17 students, section enrollment of about 30 students, total class size of 84)

	Score	Dept.	Div.	Caltech
Provided helpful comments on assignments, papers, exams	**4.93** ± 0.25	4.49	4.35	4.45
Answered questions clearly and concisely	**4.72** ± 0.56	4.45	4.36	4.46
Was well prepared for section, office hours or lab	**4.83** ± 0.50	4.63	4.52	4.52
Presented material clearly in section or lab	**4.76** ± 0.55	4.50	4.44	4.52
Overall teaching effectiveness	**4.82** ± 0.51	4.50	4.39	4.46

Thanks for being a very good TA! Recitations and office hours were very helpful. Thank you so much for staying after to continue answering questions.
Ashmeet saved me in this class! His recitations were concise and as clear as quantum can get. He's so enthusiastic and inspired me to actually learn the material :)
Ashmeet's passion and energy made me appreciate quantum!! Thank you Ashmeet!!
I really like your teaching style, enthusiasm, and how you motivated the topic you were presenting.
Ashmeet is an amazing TA who's enthusiasm about quantum mechanics and about teaching students really shines through the effort he puts into his office hours. He is always responsive to questions and answers thoroughly.

Ph2a: Vibrations and Waves, Fall 2017

(quantitative responses from 10 students, section enrollment of about 15 students, total class size of 88)

	Score	Dept.	Div.	Caltech
Provided helpful comments on assignments, papers, exams	**5.00** ± 0.00	4.50	4.40	4.40
Answered questions clearly and concisely	**4.90** ± 0.30	4.51	4.41	4.41
Was well prepared for section, office hours or lab	**4.80** ± 0.40	4.63	4.53	4.49
Presented material clearly in section or lab	**5.00** ± 0.00	4.52	4.47	4.46
Overall teaching effectiveness	**4.90** ± 0.30	4.51	4.43	4.41

Ashmeet's office hours are very helpful. He is very friendly and energetically explains problems thoroughly and clearly, and often times stays past the time he is required to help. He also offers help via email. Very helpful.

thank you very much ashmeet! your energy during recitation as always makes the rest of us very excited to learn! your patience as well is truly legendary during office hours. thank you for carrying us through the class!
I really appreciated how much effort Ashmeet put into explaining all concepts as clearly as he could to many, many students, and often explaining things multiple ways to make sure everyone understood.
thanks <3
Great teacher! Learned a lot. You can tell he's super passionate about physics so it's really refreshing going to rec! Thanks Ashmeet!!!
Best TA I've ever had. Knew the material inside and out, could answer any question, gave helpful hints. He was one of the few people who taught me the material.

Ph125c: Advanced Quantum Mechanics, Spring 2017

(quantitative responses from 8 students, total class size of 50)

	Score	Dept.	Div.	Caltech
Provided helpful comments on assignments, papers, exams	**4.88** ± 0.33	4.21	4.27	4.39
Answered questions clearly and concisely	**5.00** ± 0.00	4.12	4.22	4.40
Was well prepared for section, office hours or lab	**5.00** ± 0.00	4.28	4.34	4.50
Presented material clearly in section or lab	**4.86** ± 0.35	4.12	4.26	4.45
Overall teaching effectiveness	**4.88** ± 0.33	4.18	4.28	4.42

Very helpful!
Amazing at explaining unclear things, and homeworks were the perfect level of difficulty and very clear.
Ashmeet was the best TA I have ever had for a physics course. His sets were well-written, he stayed twice as long at his OH as required, he was available for consultation outside of his official OH, and his explanations were very thorough.
Ashmeet wrote very challenging problems, but they were interesting and rewarding to solve. When approached outside of class and office hours, he was extremely eager to help me understand both class material and homework. I'm very glad he was a TA for this class.
(same as Thom's comment:) The TAs (especially Ashmeet and Thom) had a penchant for assigning really confusing/complicated set problems so I know at least one person who's annoyed at Thom for that, but at least they were well prepared for office hours and happy to meet with students outside of OH to discuss problems and class material.

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Ph1b: Introduction to Electromagnetism, Winter 2017

(quantitative responses from 15 students, section enrollment of about 30 students, total class size of 95)

	Score	Dept.	Div.	Caltech
Provided helpful comments on assignments, papers, exams	**4.80** ± 0.54	4.32	4.32	4.41
Answered questions clearly and concisely	**5.00** ± 0.00	4.47	4.40	4.40
Was well prepared for section, office hours or lab	**5.00** ± 0.00	4.61	4.49	4.47
Presented material clearly in section or lab	**4.93** ± 0.25	4.52	4.46	4.49
Overall teaching effectiveness	**4.93** ± 0.26	4.43	4.37	4.43

Ashmeet is the best and has met with me and other students outside class for additional help. He is very good an explaining concepts.
Ashmeet is a great TA - his rec sections are detailed and cover the material very well. The examples are helpful for understanding how to apply concepts.
Ashmeet's flipped sections were more helpful when they had fewer problems; it made us feel like we could finish them, rather than feeling overwhelmed by too many problems at once.
Amazing TA!
Ashmeet is the best TA ever. He truly cares about our learning and I can tell he spends a lot of time preparing for section. I loved flipped section and I learned so much!!!
Ashmeet you're great! Honestly, I still don't really understand physics, but I came closer to it in your class than I ever have. Your office hours were so great and I appreciate how you were willing to stay later to help us. One tip: you seemed frantic every time you went a few minutes early. Unless you have somewhere to be, it's fine if you're 10-20 minutes over. The people who go to rec are the ones who care about learning the material. Anyway, thanks again!!! (you should TA ph 1c prac).
very helpful, always willing to explain things further if anyone is even a little bit lost. extremely well prepared for section (especially flipped); really puts in a lot of work and his enthusiasm for physics is almost contagious
Ashmeet was an absolutely amazing TA. I don't think there's anything I would've changed about his section.

Ph1a: Introduction to Classical Mechanics, Fall 2016

(quantitative responses from 12 students, section enrollment of about 30 students, total class size of 218)

	Score	Dept.	Div.	Caltech
Provided helpful comments on assignments, papers, exams	**4.73** ± 0.45	4.44	4.37	4.41
Answered questions clearly and concisely	**4.83** ± 0.37	4.37	4.36	4.40
Was well prepared for section, office hours or lab	**4.92** ± 0.28	4.57	4.50	4.49
Presented material clearly in section or lab	**4.92** ± 0.28	4.43	4.41	4.46
Overall teaching effectiveness	**4.92** ± 0.28	4.45	4.41	4.42

ashmeet@caltech.edu

I switched into Ashmeet's section because Ashmeet is great! He really knows what he's talking about, is incredibly quick with the chalk, and is very happy to help. He explains confusing concepts well, and explains "old" concepts (perhaps ones you thought you knew well) using different phrases that make you think about them in new ways. He makes you see how everything is related.
Ashmeet is the best TA; he made learning physics seem so much more attainable.
Ashmeet was an excellent TA!! He was very good at explaining concepts in the flipped section and working out problems in a way that was very fundamental but not confusing. The Thursday recitation sections were less helpful; often there were long derivations that I did not completely follow. However, Ashmeet clearly understands physics very well and can communicate that understanding.
Ashmeet is the greatest TA ever. Everything he presents in recitation really changes my perspective on physics. I still haven't forgotten the first recitation he held; it made me appreciate physics more! He's also very helpful and clear in his information, and he really understands physics on a spiritual level. 10/10 would recommend Ashmeet. His flipped sections were also pretty fun! I wish that I had gone to more of them because they really help with the quizzes too!
The flipped section was my most useful recitation section in any subject. :)

Ph1c: Electromagnetism and Special Relativity, Spring 2016

(quantitative responses from 18 students, section enrollment of about 30 students, total class size of 149)

	Score	Dept.	Div.	Caltech
Provided helpful comments on assignments, papers, exams	**4.93** ± 0.25	4.43	4.44	4.32
Answered questions clearly and concisely	**4.89** ± 0.46	4.43	4.46	4.37
Was well prepared for section, office hours or lab	**4.78** ± 0.71	4.61	4.55	4.44
Presented material clearly in section or lab	**4.94** ± 0.23	4.51	4.48	4.41
Overall teaching effectiveness	**4.83** ± 0.50	4.49	4.47	4.37

Posts his section notes online. Also really responsive to emails.
Ashmeet is simply the best. Only wish that we had Friday lectures with him so that he could go a bit slower on the topics. Overall amazing job, one of my favorite TAs out of any class so far.
Very helpful. Often sent emails to the entire class, and held very interesting sections.
Greatest TA I've had so far! Explained concepts clearly, always held extra recitation sections, and was very willing to help answer any questions.
Presented material at a good pace.
Very caring when I expressed my difficulties with the course. Always well-prepared.
Extremely helpful during recitation and office hours. Has well-organized notes and is able to explain complex topics in a clear and concise manner.
Ashmeet is a good TA for conceptual understanding, and for gaining a love for physics. That said, he'd be a 10/10 TA if he'd just try to do one or two examples per recitation instead of starting from the basics every single time.
Ashmeet is an amazing TA. He is very passionate about physics which makes it easier to understand since he explains concepts thoroughly.

Ph1b: Introduction to Electromagnetism, Winter 2016

(quantitative responses from 4 students, section enrollment of about 6 students, total class size of 115)

	Score	Dept.	Div.	Caltech
Provided helpful comments on assignments, papers, exams	**5.00** ± 0.00	4.54	4.40	4.36
Answered questions clearly and concisely	**5.00** ± 0.00	4.52	4.39	4.35
Was well prepared for section, office hours or lab	**5.00** ± 0.00	4.64	4.50	4.44
Presented material clearly in section or lab	**5.00** ± 0.00	4.60	4.47	4.43
Overall teaching effectiveness	**5.00** ± 0.00	4.55	4.40	4.38

Ashmeet is perhaps the greatest TA I've ever seen. From the very beginning, even with the simplest concepts of charge and electric force, he explained things in such a way that I left recitation with a deeper, more fundamental understanding of E&M.; And no matter the concept, he was always ready to help and explain further why things mattered, what the equations really meant, how to apply and connect concepts, etc. Ashmeet is an excellent TA and I really hope I'll get to have him as a TA next term.
Ashmeet is a wonderful TA. Even though only around two to three students went to his section, I would look forward to coming to this physics recitation. He knew the material very very well and explained it like he was the textbook. He is very good at explaining concepts that we wouldn't understand. I loved how passionate he was about physics and how much he cared for his three students that went to his section. He did a great job TAing this term and I hope I can have him for a TA for Physics 1C.
I learned all of the material from Ashmeet during section. He went through the derivation of the major principles carefully at a reasonable pace and made sure that everyone understood before moving on. He was willing to meet outside to go over homework and topics constantly.
My only interaction was in an office your, but Ashmeet was extremely helpful and diligent in explaining the theory such that I could answer my own questions. After meeting with Ashmeet I was able to teach other students what had confused me and so I feel that is a solid showing of the understanding I got from him.

. . . continued

Appendix - B: Welcome TA Packet

Caltech Physics: Welcome TA Packet

Resources to Help You Get Started!

For questions, comments and suggestions, please email the Physics Teaching Fellow, Ashmeet Singh at ashmeet@caltech.edu

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This "Welcome TA Packet" combines resources and pointers you might find useful while TAing at Caltech. It is organized under various headers, and you might find different sections relevant depending on your role as a TA.

We will discuss ideas, tips and tricks to hold engaging and wholesome recitations and office hours. Followed by a section which will detail out some broad points to help you in your role as a Head TA to keep the logistics of the course together. The final section will discuss strategies and ideas for effective grading.

Some resourceful people at Caltech whom you could reach out to for your TA questions and discussions:

— names of Caltech Department of Physics personnel removed to protect anonymity —

Happy TAing!

Caltech Physics: Welcome TA Packet

Resources to Help You Get Started!

Recitation Sections

The Recitation structure at Caltech is very unique! Unlike many other schools, where recitations only involve doing practice problems or discussing the homework, here at Caltech, you can get the chance to actually engage and be instrumental in full "lecture-style" classes. While each person has a different style of teaching and engaging the class, some tips and tricks can go a long way.

- It is often thought that recitations should only consist of problem solving and discussing examples. **But the essence of a recitation is much more wholesome.** You are teaching the students how to be a physicist and tie together everything that they have learned within one unified framework.

  Tying concepts, with subtleties, backed by problems should be done in a holistic manner. While you do want to make sure that you are not verbatim repeating material from the lecture, but rather engaging the students in a way that touches upon the basics while adding a new perspective on the topic, be it through a problem or a different approach.

- Interaction with the students forms a cornerstone of effective recitations. You want to try and engage everyone in class. Stop often, take inputs. Make sure everyone is following. Encourage them to ask questions and make comments in the class.

  Be patient to wait for their response when you ask for a prompt. Get comfortable with the class and think of the recitation as an interactive discussion facilitating learning. The CTLO prescribes many "Active Learning" techniques you could try in class, such as "Think-Pair-Share" or Flipped Section formats, amongst others. Make the students feel a part of the process rather than you going and just writing/showing a bunch of things at the board mechanically.

- Often, going on short, quirky tangents related to the subject matter during the recitation adds an exciting and orthogonal perspective to the topic. It breaks the monotony of the class and going outside the confines of the textbook/syllabus is something which students often appreciate.

- Being prepared is key! A good recitation is more than just knowing your material, it is showmanship and engaging the class with the power of physics. Being prepared not only includes being adept with the material, but also having thought about the best way of presenting it in a novel, exciting way, yet connecting it back with the bigger picture. Homeworks will often teach the students how to do the math correctly — you also want to convey the intuition behind those equations.

- Make sure your board work is descriptive enough, legible for students to connect with. Make sure you write big, with good spacing and organization. This can be hard at first and practice helps! Make a detailed plan before the recitation on how and what you want to cover. The math you present should be consistently done, for example, the notation, flow of thought etc. Again, remember, you are facilitating students help think like physicists.

- Make sure the projector in your class works (if you want to use it) beforehand. Have the colored chalk you need. This little preparedness on your part will go a long way in a better recitation experience for both you and the class.

- Sending your section a weekly email at the start of the week about what topics you will be covering is a great idea. Students can connect better as they can feel the continuity in things and already have a sense of what all is going to be covered. Helps connect with your section better.

- Introspect after each recitation session to get a sense on what you could improve, what was taken well by the class, what wasn't and what changes you could implement to connect better with them. Doing an amazing recitation doesn't come in one-day. Take your time and build up to it.

- Flipped Sections are a great way to engage the class in Active Learning. The format includes having your section come, one a week, to a place where there are lots of boards. Splitting the class in small groups of 2-4 and having them solve and brainstorm on a set of previously prepared problems. They work together in their group, actively discussing on the board. The TA walks around, talks with different groups, helps them work through challenging problems, nudging when it's needed and fostering an inclusive, engaging environment. Ph1 already has seen successful implementation of Flipped section formats and resources are ready for you to use (Just ask Ashmeet, the Teaching Fellow about it). The CTLO also has some logistical resources one could tap to help you more comfortable in such a format.

- While the Registrar's office allots rooms on their own for different sections and they are usually well suited — but if you are not happy with the setup of your recitation venue, you can consider changing it. Contact the Registrar's office and work with them to try looking for something more suitable. This should be done before classes start, does take some time and energy but can be worth it.

- Ending the term, the last recitation with something memorable is always good. Maybe coming up with a very exciting application or something very counter-intuitive to rapture your audience and make them remember your recitations for times to come!

- Light humor (bonus points if they are connected to physics) in class is always welcome! Just make sure it's nice, clean humor and not at the expense of anyone or any group.

Effective Office Hours

- The key is to help the students think their way through their own questions.

- It is very important to be prepared. Go over the homework problems and solutions beforehand. Do not attempt to solve things for the first time when asked a question by a student. You might understand everything but the idea is how clearly and holistically you are able to help the student solve their own problems.

- You neither want to very easily give away solutions nor do you want to be to "strict" in helping. Having a balance where you help the student think and work their way through their question by nudging them in the right direction is important. Make them think about the basics and how it connects to the problem and build from there.

- Communicate your office hours time and location well in advance to the class. Do not have office hours between 5-7pm since that is dinner and sports time for many undergrads. If your students would need access to a particular building after-hours, make sure they have it. You can contact Freddy Mora to have this setup.

- After the office hours, make a note and distill topics/concepts you felt a lot of students had problems with. These topics could be taken up again and strengthened in lecture or recitation.

Caltech Physics: Welcome TA Packet

Resources to Help You Get Started!

Head TA + TA for Advanced Classes

As Head TA for a large undergrad course, or a TA for one of the advanced courses (undergrad or grad), one of your main roles is to the bridge between the instructor(s) and the students and make sure the course logistics are flawlessly run. A few pointers/bases you might want to cover in your role:

Course Website

- The course website is one of the mainstays for having strong course logistics. Make sure the website is in place before the term starts, has all the information a student would like to know, including but not limited to lecture/recitation/office hours schedules, homework submission policy, collaboration policy, textbook details, lecture notes etc.
- The website should be regularly updated to keep up with the pace of the course, including posting homeworks and solutions. Timeline of posting should be discussed with the professor and other TAs.
- Having a course calendar (marked with homeworks, due dates etc) online is a good idea since it allows everyone a sense of the structure of the course.

Graders, Grading et al.

- You will also be responsible for managing the grading logistics for the course. Always recommended to ask for your grader's schedules, preferences, conflicts etc. before making grading assignments.
- Make sure graders are aware where to pick up the homework and where to drop off. This includes logistics like keys to the pick-up boxes (if, applicable) and Freddy Mora is the go-to person to coordinate this, if needed.
- The solutions should be made available to the graders if they already exist (such as for homework problems from previous years). If solutions do not exist, coordinate amongst the recitation TAs, graders and yourself on how to divide up writing the solutions.
- Lay out a clear late homework submission policy, and communicate it both to the graders and students. Often late homeworks submitted in the dropbox get misplaced, and one way to avoid this to the have the students send late submissions directly to the grader over email. The grader can grade it and reply to the student with a brief email mentioning where points were taken away. Discuss this with the professor and graders.
- Communicate with Freddy Mora to get the up-to-date list of student's FERPA list. If the student has waived FERPA, graders can drop off their submissions to a public pick-up location (such as a return cubby in E. Bridge or Linde Hall). Else, if the student has said not waived FERPA for Physics, graders should drop these submissions with Freddy for the student to pick them up in person.
- Maintain a detailed, up-to-date gradesheet for the course where the graders can input scores for the submissions. Have a system of marking late, missing, unnamed homeworks etc.
- Have a homework extension policy in place in discussion with the professor and other TAs and make sure the students are aware of it.

Hi class,

Welcome to Ph2a -- we have a bunch of interesting topics in Waves and Oscillations lined up for you in the coming term, and we hope you will enjoy it as much as we will enjoy teaching it.

I will be the head TA (and also a recitation TA) for the class and as we gear for the term start, here are a few announcements to help you get acquainted with the course logistics:

1. The course website is available at https://www.its.caltech.edu/~phys002/ where you can find the latest announcements, course calendar, textbook details, homework, and other resources as we go into the term.

2. Lectures will be engaged by Prof. Frank Porter as per the following schedule:
T 11:00 AM - 11:55 AM in 201 BRG
R 11:00 AM - 11:55 AM in 269 LAU

We have 3 recitation sections which meet as per the following:
Section 1 : Ashmeet Singh : WF 11:00 AM - 11:55 AM in 269 LAU
Section 2 : Jeremy Brouillet : WF 11:00 AM - 11:55 AM in B111 DWN
Section 3 : Eugene Tang : WF 1:00 PM - 1:55 PM in B111 DWN
[There has been some shuffling over the last few days so I recommend checking your Regis to make sure which section you are in]

3. The first lecture will be tomorrow, Tuesday, October 2 and the first recitation will be on Wednesday, October 3.

4. Homeworks will be due on Tuesdays at 11 am in the drop box outside 201 E. Bridge. Graded homework will be returned for FERPA waived people in the cubbies in Bridge Annex and non-FERPA waived ones can be collected from Mika in B161 W. Bridge.

5. We will be following a novel grading structure (includes both the structure of exams and how grading is done) this term for Ph2a! Please check the course website for more information.

6. Office hours for the TAs are available on the website: https://www.its.caltech.edu/~phys002/ta.html
The grading schedule will be finalized and posted on the website later this week.

7. We are looking for ombudspersons for the class. Ombudsfolk are student volunteers who represent the students of each of the undergrad houses. They collect suggestions, comments, complaints, etc, and discuss them with the course instructor and TAs at periodic meetings (free lunch!). Please select (at least) one ombuds from each house and let me know about it by end of this week.

8. We will be using Slack as a collaborative and interactive online workspace where you can ask questions, discuss concepts and brainstorm with the course instructors and your fellow classmates. Don't slack in using Slack! To join our Slack workspace, register with your Caltech email (The restriction is that you must have a Caltech IP address (use VPN if needed).) at https://join.slack.com/t/ph2a2018/signup and after which you can access it at https://ph2a2018.slack.com. You should also download the Slack app on your phone and stay connected with all the awesome physics Ph2a has to offer!

And finally, I'll be the head TA for the class and you are most welcome to approach me with any concerns/questions regarding grading, recitations or the class in general. As we strive to make the course interesting for you as possible, feel free to communicate your concerns and suggestions to us.

That's all for now, folks -- looking forward to a great term!
Let me know if you have any questions.

- As head TA, you should also guide the graders to be consistent - i.e., lay out total number of points per problem in the solutions, and also talking with graders about course-wide expectations for full credit, half credit, no credit, and glancing through early graded sets to make sure graders are not interpreting grading in vastly different ways (More pointers in the Grading Section below)

Student Interaction and Online Forums like Slack or Piazza

- Encourage a discussion forum for the class on an online platform like Piazza or Slack. Students can ask questions here, and instructor(s) can post announcements etc. One benefit of Piazza over Slack is that it allows anonymous posting and hence makes the students more comfortable in posting.

- As head TA, you will also receive a flurry of emails from students regarding a whole slew of matters (misplaced homeworks, extension requests, disputing grading etc.) — try to be proactive to respond and/or point them toward the right person/resource. It helps the students stay connected with the course.

- You can get hold of the class roster through Regis. If you don't have access to it, email the Registrar's office and they'll provide you with it.

TA and Ombuds meetings

- As head TA, you should also plan — in discussion with the professor and other TAs — periodic meetings for the course where you all can sit together and discuss the progress, report any updates and do course corrections along the way.

- For the larger courses, you should also ask for Ombudspeople from the class. Ombudsfolk are student volunteers who represent the students of each of the undergrad houses. They collect suggestions, comments, complaints, etc, and discuss them with the course instructor and TAs at periodic meetings. Usually one ombuds from each undergrad house.

- To coordinate TA meetings, room reservations and lunch orders (if you have them), please get in touch with Freddy Mora.

Welcome Email to the Class

Before classes begin, it is a good idea to send a Welcome email to the whole class to get everyone on the same page with the course logistics and structure. It helps answer most of the initial questions students have and helps them get oriented. An example of such a welcome email is charted below (only to be taken as a template, particular course details are old from last year)

…. on the next page.