Teaching portfolio

Bence Béky

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1 Teaching philosophy

Learning is an adventure, and I often enjoy the moment of revelation just as much as the end product of knowledge. Teaching is to share this joy, and my reward is to see the students in their moment of comprehension.

However, I had to learn that teaching is more than just sharing ideas and explaining concepts in some distilled, foolproof manner. Students are different in their background, motivation, and learning styles. What works for one might not work for the other. The first thing for me was to recognize my own learning style: I prefer written material to live explanation, and I prefer abstract, concise presentation to examples and analogies. I had to understand and accept this before I could relate to students who operate in other learning modes. This allows me to more mindfully present both examples and abstract formalism, and explain them both in spoken words and writing on the blackboard, to make sure that every student can relate to the material in their preferred way.

There are, however, universal messages. I am not afraid to display my love for what I teach, because entusiasm is contagious to everybody. I want them to walk away from my class thinking two things: “I can do this”, and “I like doing this”. The first one is the fruit of careful presentation, the second one of the atmosphere.

My little advantage over tenured professors is that I am closer to my students in age, so it is easier for them to relate to me, if I set up the scene correctly. I encourage questions and class discussion by paying close attention to my students, making sure that I understand what they have difficulties with. I also use positive reinforcement in the form of “That is correct/a great idea. Another way to think about it is . . . ”. These are very important steps towards making the students feel comfortable to discuss their ideas in the classroom. However, in the spirit of professional conduct, I am friendly but do not try to be their friend. Proper voice projection and body language never failed me to maintain discipline, while I use a warm tone and good sense of humor to build rapport.

Once this working environment is set up, I like to keep students engaged with the material by involving them in exploring it in a broader context. An efficient way to do so is to ask them “why” questions, so that they make connections to what they already know. This also helps them learn the material by rediscovering things on their own, and thereby providing them with a way of reconstructing it in the future. Along the same line, I take every opportunity to go through my sanity checks and ways of reconstruction as I present the material, to reinforce the intricate connections. The most common of these methods in mathematics and physics are looking at extreme cases and dimensions.

Another great way of putting things in context is bringing in examples from other domains of science or from everyday experience. This is also important for the transparency of teaching, so that students know why they have to learn about things like Fourier transformation that seem too abstract if taken out of context. Again, there is a healthy balance between teaching in abstract formalism and teaching through examples.

When teaching mathematics and physics, one has to acknowledge that these subjects are fairly unpopular. As a true admirer of these disciplines, my motivation to share my love for them is emotional. However, in addition to displaying my enthusiasm, there are other ways to stir up the students' interest: by emphasizing how not only their knowledge, but also their quantitive and abstraction skills are transferable. Some students will be motivated by this idea, whereas some are motivated by the inherent beauty of mathematics. Some prefer abstract terms, some examples. Some learn more from participating in a lecture, some from working through a book. As a teacher, my job is to appeal to all students by giving them all the tools they need, and guiding them through the adventure of learning.

2 Teaching experience

I have experienced a wide range of teaching: from grading homeworks to semester-long lecturing, from speaking in front of middle schoolers to leading problem sessions for graduate students, from teaching mathematics and physics concentrators to talking to the general public. This section provides a detailed account of my teaching activities.

2004 autumn Teaching assistant for Computation Theory at Tampere University of Technology, Finland. My first time teaching problem sessions, to a very reserved group of students. Though the lack of interaction during class felt discouraging at first, I soon realized that even if the deeply rooted classroom culture discourages student participation, I was able to guide them by talking to them one on one or via e-mails.

2005 summer Assistant coach of the Finnish and Estonian teams for the International Physics Olimpiad, Kuressaare, Estonia. This was a unique opportunity to spend a week with the best high school students selected to participate in the IPhO. While the Estonian coach Jaan Kalda lead the problem sessions in a classroom setting, my role was more informal: I had one-on-one or small group discussions with the students in our free time, not only about the material they needed to know, but also about my recent experience at the Olimpiads, and university life. This was my first experience mentoring students.

2005 autumn, 2006 spring, and 2006 autumn Teaching assistant for the Pólya–Szegő mathematical problem solving seminar, Budapest University of Technology and Economics (BME), Hungary. This is a preparatory course for the International Mathematics Competition. With a few other students, we took turns writing up problems, leading the discussion on their solutions, and grading. It was very inspiring to work with the enrollees, as many of them were aspiring or previous competitors at IMC themselves.

2006 spring Teaching assistant for Probability Theory 2, BME, Hungary. Most students of this course were mathematics majors, and due to a scheduling conflict, a separate problem session was offered for the few physics majors who chose this course as an elective. I was fortunate enough to lead this problem session, and it was a real challange for me prepare, as these physics majors were really good at abstract mathematics. It was also a great opportunity to talk about how the material relates to important physical principles and phenomena.

2006 autumn Teaching assistant for Probability Theory for electrotechnical majors, BME, Hungary. This was my first time teaching non-science majors, prompting me to convey my enthusiasm in a different way than to science majors. I learnt to present the material via more specific and more life-like examples, to use more graphical representations, and to relate to other disciplines in order to engage my students.

2007 autumn and 2008 spring Teaching assistant for Calculus 1 and 2 for physics students, BME, Hungary. I was grading calculus homework for the same group of students for two semesters. This involved interactions very different from my previous teaching experience: the course was set up so that I never met the students in person, and I had to fight hard to get their attention in writing. I made a habit of typing up detailed feedback for the entire class in addition to my handwritten comments on the individual papers. This had the additional benefit that students could learn from one another's mistakes.

2008-01-25 Invited consultant on a board meeting of the Technical Advisory Comittee of the Hungarian Education Research and Development Institute, Budapest, Hungary. This was a unique event when a state authority on education policy solicitated student input in the form of a round table discussion. Two dozen students were invited based on our outstanding competition results in natural sciences, and we were asked to state our opinion not only on the matter of elite education, but also on the curriculum and the efficiency of different forms of teaching. I found it really inspiring to have an open discussion with experts on pedagogy.

2008-06-08 to 06-21 Observer at the Texas State University Junior Summer Math Camp, San Marcos, TX. This summer program doubles as a workshop for middle school teachers: they observe the classes being taught by leading teachers in the mornings, and discuss teaching techniques and curriculum in the afternoons. I really enjoyed watching a different educational system at work, especially with experienced teachers who knew how to engage students.

2008-06-22 to 07-26 Textbook editor and assistant coach of the Hong Kong Primary World Mathematics Contest team, San Marcos, TX. During the Honors Summer Math Camp, I participated in editing Math Explorations Part II, a middle school algebra textbook, together with math professors at Texas State University and local middle school teachers. In the evenings, I helped coaching a team of four pupils for the Hong Kong Primary World Mathematics Contest, using competition problems I had collected since middle school.

2009-04-30 to 05-03 Jury member at NYIFFF national physics team contest, Szigliget, Hungary. This four day long annual competition extends the domain of classroom physics: from quizzes to daylong problems, both theoretical and experimental, with privimite tools and instruments, at and around the campsite, everything about this event is there to motivate us to apply our abstract knowledge to the real life surrounding us. After competing for five years, I was invited to invent and grade problems and mentor students as a jury member.

2011 autumn Teaching fellow for Radiative Processes in Astrophysics, a graduate course at Harvard. This is the fundamental course in the graduate program in astronomy, covering the theory of radiative processes together with applications in many different fields of astrophysics. My duty was to help students with their homeworks, grade their solutions, and lead a weekly problem session.

2012 autumn Teaching fellow for Multivariable Calculus, an undergraduate course at Harvard. This course is taken mostly by first-year students with a wide range of intended majors, including natural sciences, life sciences, and humanities. I was teaching a section of twenty students three hours a week. My duty was to prepare these classes based on the course syllabus, choose example problems and prepare handouts, provide additional tutoring during office hours twice a week, and grade midterms and the final exam. My course assistant was in charge of the problem sessions and grading the homework. All section leaders got together weekly to exchange their ideas, and talk about difficulties of each concept. This was my first real semester-long lecturing experience, and I really enjoyed the challanges it posed.

2012 January and 2013 January Talk to middle school students, Hungary. I was invited by middle school teacher relatives to talk about astronomy in general and pursuing a career in astronomy at Gádor Általános Iskola in 2012, and at Szemere Bertalan Általános Iskola a year later. Both times I delivered a slide show presentation to approximately fifty students, covering the basics of observational astronomy and scales of the Universe, with special emphasis on my motivations along the way to graduate school. I really enjoyed this opportunity to evaluate my educational decisions and highlight the influences in a way that young kids could relate to.

2013-03-22 Public lecture organized by the Hungarian Association of Massachusetts. I was invited to talk about my research area to the Hungarian community in the Boston area. The Association has been running this series of talks by local researchers in all areas for a long time. This was my first scientific talk to the general audience, and I was glad to experience again how easy it is to engage the audience with astronomy, the childhood interest of many people. However, I realized that this ease might be deceptive, and had to prepare to entertain an audience of very diverse background in astronomy.

3 Learning to teach

This section describes the courses and seminars I have taken that relate to teaching, educating, or communication in a more general sense.

2010-10-21 to 12-16 Public speaking seminar David Aguilar from the Science Education Department of the Harvard–Smithsonian Center for Astrophysics offered a seminar for graduate students and visiting students on public speaking. The seminar had nine sessions, covered areas from enunciating and body language to slide shows, included preparing for multiple short presentations, and made extensive use of David's wide range of experience with public lectures everywhere from observatories and planetariums to cruiseships, with marketing, and television.

2010-11-06 Communicating science seminar This one-day event was offered by Cornelia Dean, science editor at The New York Times. She focused on communication with general audience in writing and in person, with many hands-on exercises.

2011 autumn Teaching Mathematics for Undergraduates Seminar Also known as Mathematics 300, this is a mandatory course for mathematics graduate students offered by Harvard Mathematics Department. In addition to excercises in lecturing, student interactions in the classroom, during office hours, and in e-mails, we could talk to undergraduates and more experienced graduate students about their experiences of undergraduate mathematics courses at Harvard. Three ten to fifteen-minute teaching sessions were videotaped and are available on request.

2011-02-22 Public speaking as performing art This was a workshop offered by Nancy Houfek, resident vocal coach at the American Repertory

Theatre. She teaches voice projection through breathing and other hands-on excercises.

2011-06-28 to 07-14 Advanced communications practices for teachers and scholars This was a six session seminar lead by Elise Morrison and Marlon Kuzmick, organized by the Derek Bok Center for Teaching and Learning. The seminar covered oral, written, and visual communication, discussing different audiences, and providing many excercises, including elevator pitch, explaining research at a family event, writing abstracts, and presenting a course syllabus.

Bok Center Teaching Conference I have participated in the Bok Center Teaching Conference four times: on 2011-08-24 and 08-25, on 2012-01-17 and 01-18, on 2012-08-29 and 08-30, and on 2013-01-24.

4 Example material

This section presents the following materials I wrote:

- Course syllabus for Radiative Processes in Astrophysics,
- the first two pages of Problem Set 1 solutions for Radiative Processes in Astrophysics,
- two example handouts for my Multivariable Calculus section.

Course syllabus
Astronomy 150 — Radiative Processes in Astrophysics
2011 fall

instructor	Ramesh Narayan rnarayan@cfa.harvard.edu
teaching assistant	Bence Béky bbeky@cfa.harvard.edu
lectures	Mondays and Wednesdays 13:00 – 14:30 Sever Hall 214
sections	Fridays 13:15 – 14:15 various locations
exam group	7, 8
prerequisite	Physics 143a or equivalent
catalog number	8993

This document is available online on the course website at `my.harvard.edu`.

Goals This is a core course of the graduate program in astronomy, mandatory for first year students. The material covered in this course is essential for every other astronomy course, as well as for research in almost any area within astronomy. Undergraduates concentrating in astrophysics or physics, and graduate students from other departments are also welcome to take the course.

Lectures Lectures are blackboard style. Attendance is recommended. See schedule and topics on page 3.

Sections Sections are informal discussions about the material. Attendance is recommended. Students are encouraged to ask questions, and proactively share their understanding of the material at the blackboard. At sections following a homework assignment deadline, solutions for selected problems will be presented by the students on a voluntary basis, followed by an open discussion. Note that even though sections are the primary forum for questions, students are encouraged to contact the teaching assistant in private should they feel a need for it.
There will be sections every Friday from September 9 to November 4, on November 18, and on December 2. There will be a review section on December 12, before the final exam.

Textbook The course covers the book Radiative Processes in Astrophysics by G. B. Rybicki and A. P. Lightman. It is recommended for students to purchase the book as a reference and supplement to the lectures. There is funding available for buying the book for graduate students at the Department of Astronomy. Also, several copies are available at Wolbach library for one day loan, under call numbers `QB461.R88` and `QB461.R88X`.

Problem sets There will be eleven problem sets assigned throughout the semester according to the schedule below. Each problem set will consist of two to four problems relevant to the most recent lectures. Solutions can be submitted on paper, or electronically on the course website. The deadline is the beginning of a Wednesday lecture. One late solution will be accepted from each student during the entire semester, but only a portion of the credit will be granted, depending on the amount of delay.

	assigned	due
0	Aug 31	Sep 7
1	Sep 7	Sep 14
2	Sep 14	Sep 21
3	Sep 21	Sep 28
4	Sep 28	Oct 5
5	Oct 5	Oct 12
6	Oct 19	Oct 26
7	Oct 26	Nov 2
8	Nov 2	Nov 9
9	Nov 9	Nov 16
10	Nov 16	Nov 30

Exams There will be a one hour midterm and a three hour final exam, see lecture schedule below. These are in-class, closed book exams. Students are allowed to individually prepare in advance and consult during the exam one letter size (215.9 mm by 279.4 mm) page (a single side of a sheet) of constants, formulae and equations ("cheat sheet") for the mid-term exam, and two letter size pages (both sides of a single sheet or one side of each of two sheets) for the final exam. The cheat sheet can be handwritten or typeset. Calculators are allowed on the exams. Location of the exams will be announced later.

Grading

problem sets	40% of final grade	eleven problem sets in total
midterm exam	15% of final grade	one hour exam on October 17
final exam	45% of final grade	three hour exam on December 14

Policy on collaboration Collaboration on homework assignments is neither encouraged nor discouraged. Students are required to indicate on their assignments if they received substantial help from other students in solving the problems. On the mid-term and final exams, collaboration and consulting notes and books is not allowed, except for the cheat sheet prepared by the student.

Lecture schedule

Aug 31	W	Introduction: specific intensity and its moments
Sep 5	M	*Labor Day*
Sep 7	W	Radiative transfer equation
Sep 12	M	Thermal radiation, diffusion
Sep 14	W	Einstein coefficients, masers
Sep 19	M	Review: Maxwell's equations, electromagnetic waves
Sep 21	W	Spectrum, polarization
Sep 26	M	Liénard–Wiechart potentials
Sep 28	W	Larmor's formula, Thomson scattering
Oct 3	M	Thermal bremsstrahlung
Oct 5	W	Review: special relativity, four-vectors
Oct 10	M	*Columbus Day*
Oct 12	W	Field transformations
Oct 17	M	Relativistic beaming
Oct 19	W	**Midterm exam** at time and location of lecture
Oct 24	M	Synchrotron radiation: introduction
Oct 26	W	Synchrotron radiation: power-law spectra, cooling
Oct 31	M	Synchrotron self-absorption
Nov 2	W	Scattering of photons by electrons
Nov 7	M	Inverse compton radiation: power-law spectra
Nov 9	W	Synchrotron self-compton, external compton
Nov 14	M	Plasma frequency, Faraday rotation
Nov 16	W	Pair processes
Nov 21	M	Atomic structure, hydrogen atom
Nov 23	W	*Thanksgiving Recess*
Nov 28	M	Atomic spectra
Nov 30	W	Molecular spectra
Dec 14	W	**Final exam** from 14:00 to 17:00 in Harvard Hall 103

Astronomy 150, Fall 2011 — Problem Set 1

General comments

Good job! Well done, everybody!

A little bit more specific comments

1. You save yourself some effort if you express I in terms of τ instead of α_0 (less ugly square roots). In any case, since α and τ are proportional for fixed values of R, b, B_0, and I_0, it is desirable to have only one of them in your final expression of I, otherwise it might happen that you are left with terms that look different but in fact cancel out.

   If you derived the asymptotic behavior at $\tau \to 0$ up to the τ term, and at $\tau \to \infty$ up to the $\frac{1}{\tau}$ term, then you got an extra point. If you didn't, you might want to take a look at the result below, it explains why $I > I_0$ for small impact parameters and $I < I_0$ for large ones when τ is small.

2. Keep in mind that τ and σ are not physical distances, therefore you can not write up $\tau_\nu = \mu\sigma_\nu$ right away. I'm especially not convinced when α is not constant but a function of z. Please compare $\mathrm{d}\tau_\nu$ and $\mathrm{d}\sigma_\nu$ first for fixed z, and then draw your conclusions, otherwise you risk losing a point.

   In question (c), you might have the impression that you are expected to use the result of (b). This is a correct impression, and it authorizes you to assume that the medium is optically thick, therefore only the outer shells come into play, which can be approximated as parallel planes.

   As a side comment, I would also like to point out that when you plot $I(b)$, it is slightly misleading to set the minimum of your vertical axis to be the minimum of $I(b)$. It might give an innocent observer the wrong impression that I actually diminishes at $b = R$. Needless to say, this is a matter of taste, therefore it does not influence your points.

3. You all did great on this problem. Many of you realized that the radiation force has the same r dependence as the gravity, and thus its integral must also look the same. However, it is not enough to just write down the corresponding formula, you need to explain it briefly.

4. To say that the Planck function really has a peak at $h\nu = 2.82kT$, you have to check that the derivative is negative for smaller frequencies and positive for larger ones. Otherwise it could be a minimum, or a stationary point which is not an extremum. In any case, I was impressed by the variety of approximation methods you've used to attack this problem.

   By numerical integration, we mean not symbolic, exact integration. The former uses some numerical method, evaluating the function at certain places and adding up the values with certain coefficients. The latter involves integration by parts, integration by substitution, and integration tables to get an exact result. Therefore `integrate` in Alpha is not an acceptable method for this problem, but it would have been unfair on my part not to give you full credit for it, since it takes almost exactly as much effort as `NIntegrate` in Mathematica.

Solutions

Numbered equations refer to the Problem Set, lettered ones to this document.

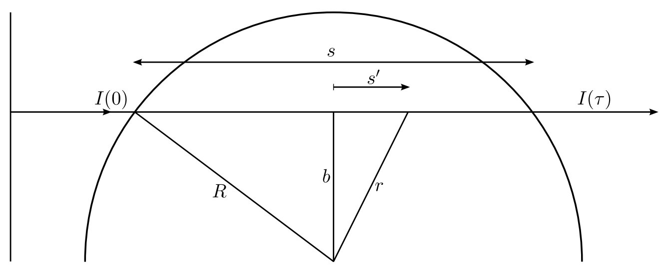
1. (a) There is no absorption or emission outside the cloud along the path of the ray, therefore we only need to solve the radiative transfer equation in the inside of the cloud. It is a ray of intensity I_0 that enters the cloud, and a distant observer detects the intensity with which the ray exits the cloud.

Denote the length of the chord along which light travels in the cloud by s. Then

$$\left(\frac{s}{2}\right)^2 + b^2 = R^2.$$

Let us parametrize the path of the ray first with the physical distance s', which is chosen to be zero at the point closest to the center of the cloud, positive at points which light reaches after having passed this point, and negative before. Then s' runs from $-\frac{s}{2}$ to $\frac{s}{2}$ inside the cloud. See figure below. At any point on the chord, we have

$$s'^2 + b^2 = r^2. \tag{A}$$



Now introduce $\tau' = \alpha s'$, the optical depth that we use to parametrize the path of the ray inside the cloud. τ' runs from $-\frac{\tau}{2} = -\frac{\alpha s}{2}$ to $\frac{\tau}{2} = \frac{\alpha s}{2}$, and the total optical length of the cloud at impact parameter b is:

$$\tau = \alpha s = 2\alpha\sqrt{R^2 - b^2}, \tag{B}$$

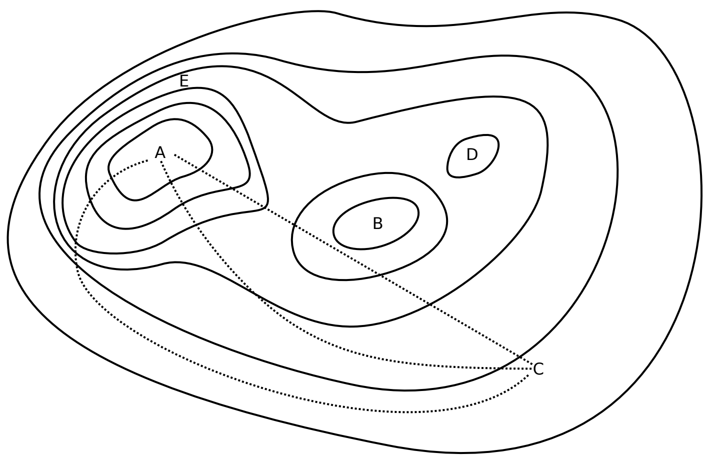
$$\frac{\tau^2}{4\alpha^2 R^2} = 1 - \frac{b^2}{R^2}. \tag{C}$$

Now that we can describe the points along the path of the ray by the optical depth τ', the next step is to express the source function inside the cloud as a function of τ', using Equations (1) and (A):

$$S = B_0\left(1 - \frac{r^2}{R^2}\right) = B_0\left(1 - \frac{s'^2 + b^2}{R^2}\right) = B_0\left(1 - \frac{\frac{\tau'^2}{\alpha^2} + b^2}{R^2}\right). \tag{D}$$

1. Linearization Consider the function $f(x,y) = x^4 - 4(x-1)^2 + y^2$. Calculate its linearization $L(x,y)$ at the point $(x_0, y_0) = (1,1)$. Calculate and compare the values of $f(x,y)$ and $L(x,y)$ at the points $(0,0)$, $(0,1)$, and $(2,1)$.

2. Topographic map Consider the topographic map of the area around mountain peaks A and B below. The solid curves are contour lines at equal altitude spacing.

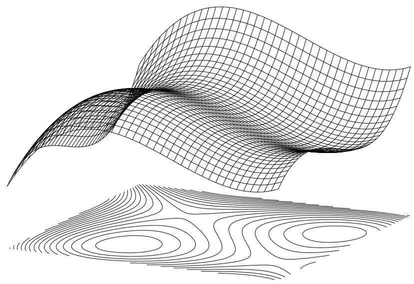


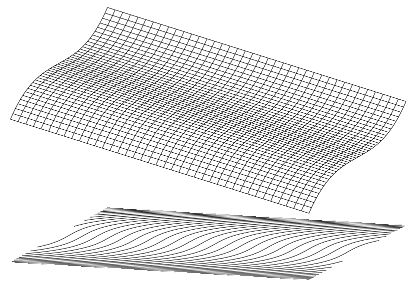
(a) Arrange the points marked by A, B, C, D, and E in increasing order of altitude.

(b) Is the terrain steeper at point C or E? What about point A?

(c) Which path would you choose to hike from C to A among the three options marked with dotted lines? Why?

3. Road trip The average fuel economy of new passanger vehicles sold today in the US is 25 mpg, and it is increasing at a rate of 0.75 mpg/year. The gas price today is 4 dollars/gallon, increasing at a rate of 0.5 dollars/gallon/year. What is the price of gas necessary to travel 100 miles in an average new car, at what is its rate of change?





1. Find and classify all critical points of $f(x,y) = x^3 - 2x^2 - 7x + y^3 + y^2 - 5y$ using the second derivative test. Compare your results to the plot of $f(x,y)$ on the left.

2. Let $f(x,y) = x^3 + 3y$ and $g(x,y) = x^2 + y^2$. Find the extrema of $f(x,y)$ subject to the constraint $g(x,y) = 2$. Compare your results to the plot of $f(x,y)$ on the right.

5 Feedback

This section presents examples of feedback on my teaching at Harvard University written by students at the end of each semester.

Radiative Processes in Astrophysics

> Bence returned assignments on time with useful feedback. He also generated much enthusiasm during his skillful explanations of the material.
>
> Bence is an excellent and fun TF. He prepares a lot for his sections and gives detailed homework problem solutions. He also is very careful at grading homework and takes the effort to understand your misconceptions and correct them. Bence is also confident about the material and was great at answering questions students had.
>
> The schedule of returning assignments so promptly was amazing and I definitely appreciate the time and effort involved with that. Solutions were complete and helpful.

Multivariable Calculus

> The lessons were well-planned. We didn't run out of time, and we were never too far ahead. My questions in class were always answered.
>
> The lessons were very thorough, and left no questions unanswered.
>
> At first it seemed that Bence's enthusiasm was forced, but as a class we quickly came to see it was genuine. At times Bence's explanations were confusing, but he was always available to help with his explanations and I always walked away from personal meetings with a much better understanding of the material.
>
> He is very enthusiastic and has a real passion for his subject (math as well as physics)