PREP 2010 Workshop Proposal

Using Sage in the Calculus Sequence

Background Data:

Name and affiliation of directors:
> Byungchul Cha, Muhlenberg College
> Karl-Dieter Crisman, Gordon College
> Jason Grout, Drake University

Contact information of program directors:
> Phone numbers and email addresses:
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Dates for proposed program:
> We propose the online component to be during a week to be determined in June or July 2010. Six weeks before the workshop, we will set up an email list for all participants and begin surveying them about any calculus topics they would particularly liked emphasized during the workshop. In the three weeks before the online workshop, each participant will sign up for an online Sage account on the dedicated server and work through a simple tutorial to ensure understanding of the basics of the software. During that time, the live collaboration software will be distributed and tested as well. Participants who wish to download Sage will also do so during this period, with assistance available from the directors. Finally, during the fall of 2010, participants will be expected to use Sage in teaching and produce several sample worksheets. In early January 2011, the results will be shared with the rest of the larger mathematical community on the main Sage website, as well as at the Joint Math Meetings as appropriate.

Location of proposed program:
> The proposed workshop would be live and online during the scheduled workshop week, with an online server housed at the University of Washington for the math software. The directors would work together onsite at Gordon College during this time.

Title:
> "Using Sage in the Calculus Sequence"

Abstract:
> Sage (http://www.sagemath.org) is a free and open-source mathematics software system which combines many existing packages into a common interface, provides strong computational power comparable to other mainstream systems, and a unique online notebook interface which makes experimentation and

collaboration easy. This online workshop focuses on the use of Sage in teaching the calculus sequence. Participants will familiarize themselves with basic skills needed to use Sage in the classroom setting. During the workshop, participants will learn how to use many capabilities of Sage relevant to teaching calculus. Participants will produce several new Sage worksheets to be used in their own calculus classes and will share resources with each other. Prior knowledge or experience of Sage is *not* assumed, and introductory materials will be distributed to participants prior to the workshop. As the workshop is online, participants will need a computer, a sufficiently fast, dedicated internet connection, and a microphone.

Narrative:

Overview of the program:

In this workshop, participants will be introduced to the Sage mathematical software system, with an emphasis on use in the calculus sequence. The main goal will be to develop participants' skills with Sage sufficient to create, publish, use, and share interactive online Sage worksheets in teaching calculus. For example, online worksheets may involve Sage's powerful symbolic and plotting capabilities combined with buttons, sliders, and other controls that let students explore a topic without any prior knowledge of Sage.

The preparatory component will mostly consist of familiarization with absolute basics of the software, while post-workshop activity will have as its goal a significant, freely available body of useful resources for the teaching community.

The general structure of the one-week intensive component will be two daily online sessions, with participants connecting via audio and screen-sharing. Usually one daily session will be more focused on how to calculate and convey mathematics content using Sage, the other on more technical computer-related issues or topical questions (though there will also be ample opportunity to share participant experience and interest as well). By the end of the intensive component, we expect each participant to have built several new worksheets to be used in teaching calculus in the upcoming academic year.

Description of the program:

We expect that participants will be familiar with the idea of using a CAS or similar software in the classroom, but will not expect that they will have extensive experience with this. Hence, the pre-workshop preparatory period will mostly be devoted to acquiring the most basic familiarity with Sage. Participants will join an email list and be given an account on a special dedicated Sage server (participants will not need to install Sage on their computers). Each participant will be expected to successfully log in to this server and work through a special tutorial designed specifically for this workshop (beginning with using Sage to compute 2+2). Optionally, participants may also download Sage and install it on their own computers (we will provide some assistance, if necessary). We will also expect participants to use the pre-workshop preparation time to view pre-designated Sage documentation and worksheets related to calculus.

During the pre-workshop preparation, we will survey the participants about specific topics that are most relevant to their needs or they would like addressed in the workshop. We will also ask about previous CAS or Sage experience, so that we may be able to better customize the workshop to the background and pedagogical needs of the participants, where appropriate.

Finally, the participants will download and test the connectivity and collaboration software selected by the MAA with the program directors during the two weeks before the workshop. All participants should have a reasonably fast, dedicated, Internet connection and access to a microphone.

The one-week workshop will be structured with daily morning and afternoon time sessions, each lasting approximately two hours (e.g., 11AM-1PM and 3PM-5PM Eastern time). We plan for at least one "teaching session" each day, which will focus on teaching, exemplifying, and sharing ideas for how to use Sage to teach specific mathematical content in the calculus sequence. We will also have almost every day a "technical session" which will focus on the "nut-and-bolts" involved in using Sage in teaching. Generally, we will use screen sharing and a published Sage worksheet template to direct

the discussion. Participants will be able to copy the template and modify their copy as the session proceeds.

During the week, participants will be guided in creating worksheets of their own to use in their courses. In several "sharing" sessions, we will use the collaboration features of Sage to offer live suggestions on participants' worksheets, which will then be published to the whole group instantaneously and discussed together.

We expect to be flexible in our topics of discussion, especially toward the end of the week, in order to be able to address topics in which many participants indicate great interest or experience (e.g., a specific calculus topic, or coupling math software with online teaching or online texts). We also expect all sessions to have significant time for discussion of questions. We do not anticipate bringing outside presenters.

A tentative outline of the intensive component sessions is detailed below.

Monday AM (technical)– Introduction: We (re-)introduce Sage and the goals of the workshop to the participants. This includes a discussion of software in the classroom and different paradigms for its use. We also include an introduction to basic non-programming features of Sage, such as LaTeX, the included online word-processor, and the interactive help system.

Monday PM (teaching)– Math Content I: We introduce the basics of symbolic variables, functions (especially the issue of *callable* functions), and 2D plotting capabilities in Sage. We also discuss homework attempts from the first session and follow-up questions about the aspects of Sage discussed in the first session.

Tuesday AM (teaching)– Math Content II: We cover the basics of single-variable calculus using Sage. This includes both commands and pedagogical ideas for doing limits, derivatives, integrals, and series. We will also showcase several popular existing interactive worksheets for things like Newton's method and polynomial approximation with Taylor series.

Tuesday PM (technical)– Programming: We give an introduction to (only) the easiest and

most useful features of the Sage language (the industry-standard Python computer language) suitable for the classroom, via *explicit* examples from presenters' class-tested worksheets. Experience teaches that this should particularly include the list structure, since the notation to build lists is similar to set builder notation, and lists as input allow multiple plots or computations. However, as participant interest and ability permits, other things such as looping or conditions may be introduced in a specific mathematical context.

Wednesday AM (teaching)– Sharing I: The primary focus of this session is for participants to share their first attempts at creating their own worksheets. We expect significant time to be devoted to answering questions and discussing participants' worksheets.

Wednesday PM (teaching)– Math Content III: This session will focus on the basics of doing multivariable calculus in Sage. This will include some mention of vectors and matrices in Sage and 3D plotting. However, specific content (e.g., whether we talk about tangent planes, vector fields, etc.) will depend on participant interest and curricula, as surveyed earlier in the week.

Thursday AM (teaching)– Class Use of Sage: We cover practical aspects of using Sage in a course. While we discuss Sage specifically, participants also share experiences with each other and discuss the broader question of technology and student motivation and effective pedagogy using technology. As time permits, we discuss using Sage in class demonstrations, outside of class (e.g., for labs), on homework, using Sage to prepare tests, etc.

Thursday PM (technical)– Technical matters: There are a host of other non-mathematical topics of which basic understanding can greatly enhance the use of Sage in teaching. We discuss some of them in this session, as determined by the collective interest of participants. Some of the most likely topics include how to create interactive cells ("Sagelets"), setting up online Sage servers, and using Sage on different operating systems.

Friday AM (teaching)– Sharing II: As we come to the close of the intensive component, the whole group shares and critiques each others' improved worksheets. We expect this to lead to a substantial time of follow-up questions, particularly regarding the three math content sessions or closely related math content areas (e.g. differential equations).

Friday PM – Wrap-Up: During this final session, we hope to entertain final questions, particularly of a more general nature (including using Sage in courses other than calculus, e.g., number theory, linear algebra, graph theory, etc.). We also plan to spend some time helping participants plan specifics of their use of Sage in the upcoming academic year and our plans for sharing resources with each other beyond the workshop group.

By the end of the week, we expect each participant (or group, if applicable) will have two or three good worksheets for immediate use in a course; our hope is that at least one of these per participant will be entirely of their own creation, while others may be modifications of currently existing material. Participants would commit to sharing their improved versions more broadly, after a period of classroom testing.

Sage has a good existing infrastructure to support new users, including several very friendly and supportive email lists (one devoted specifically to using Sage in education) and a wiki. We expect participants to actively use the Sage support lists for continuing support and to participate in the Sage educational issues email list with pedagogical advice or questions. Finally, as instructors start evaluating feedback from their experiences in 2011, we will ask participants to contribute their most successful experiences and resources to an organized collection of Sage resources.

Facilities and Resources:

This workshop will be held online, so facilities required are minimal. Nonresident directors will be provided with low-cost on-campus housing and board, and an appropriate conference area will be provided during sessions. Each director will have

access to a computer with a microphone for using the collaboration software, and with Firefox or some other standards-compliant browser for using the Sage notebook interface. (Participants are expected to provide their own comparable setup.)

Experience and capability of organizers:

Byungchul Cha received his B.A. degree from Korea Advanced Institute of Science and Technology, and Ph.D. from Johns Hopkins University. He is now teaching at Muhlenberg College. He has used computer algebra systems such as Mathematica, Maple, GP/Pari and Sage in his teaching of undergraduate courses. He co-organized an MAA Contributed Paper Session on "Use of technology in abstract algebra and number theory" at the Joint Mathematics Meetings in 2007. He has been using Sage in his research since 2007 and in teaching since 2008.

Karl-Dieter Crisman earned a BA in math from Northwestern University and a PhD from the University of Chicago, arriving at Gordon College in 2005. He has used Sage with undergraduates from calculus to research for two and a half years (making him an "early adopter"), and has actively contributed to the code and documentation for the last year and a half. He will be leading the Northeast Section NExT in a Sage seminar this fall, and is also planning a separate teaching-related module in conjunction with a larger Sage event in the Boston area this fall. He has presented on Sage in the classroom at sessions of the MAA, AMS, ACMS, and ECCAD, and co-organized a panel on open source software at the 2009 Joint Mathematics Meetings.

Jason Grout earned a BS at Missouri State University and an MS and PhD from Brigham Young University. He completed a postdoc at Iowa State University and has recently joined Drake University. Jason has contributed extensively to the Sage code base over the last three years in the linear algebra, graph theory, plotting, and online notebook components of Sage. He helped develop the online "interact" feature of Sage and integrated an online word processor into Sage. Jason has used Sage in research and

also in teaching a number of courses over the last several years, and has given several presentations and tutorials on Sage, including at the Joint Meetings and the 2009 MathFest.

We expect that all three organizers will contribute pedagogical input and lead a couple of the daily sessions at the beginning, depending on how they have used Sage in calculus (e.g. not all of us have recently taught multivariable, and some have more experience using "lab"-type worksheets). However, we anticipate that Jason will take the lead in the more technical programming-related components, while Karl-Dieter (being on location ahead of time) will deal more heavily with organization elements.

Budget:

Our proposed budget totals $9800. We have budgeted $2500 for each of the three program directors as a stipend. The technical support and housing costs are directly from quotes from the relevant institutions, while the travel and office estimates are best guesses based on sample PREP proposals and current airfares. We have *not* included collaboration software in the budget, as instructed by the MAA Sponsored Programs Coordinator, Dan Connor.

$300   Technical support and setup for Sage server
$500   Miscellaneous office materials and supplies
$600   Program director travel
$900   Program director housing and board
$7500 Program directors' stipends

Letters of Support:

Letters of support from the Provost of Gordon College, Mark Sargent, and the chair of the mathematics department at the University of Washington, Selim Tuncel, will be attached separately and/or sent via normal mail as they deem appropriate.