CAS/GRS New Course Proposal Form
To be used only for proposing new CAS courses without BU Hub credit as well as for all new GRS courses.

This completed form and all required documents should be submitted as PDF files to either Sr. Academic Administrator Peter Law pgl@bu.edu (for CAS and CAS/GRS “piggyback” courses) or to Graduate Services Associate Casey Dziuba grsgs@bu.edu (for GRS-only courses). Please contact them for information or assistance, if necessary.

DEPARTMENT OR PROGRAM: Computer Science DATE SUBMITTED: March 1, 2018

COURSE NUMBER (include college code—CAS or GRS): CAS CS 581

NOTE: A course number cannot be reused if a different course using that number has been offered in the past five years.

COURSE TITLE: Computational Fabrication

INSTRUCTOR(S): Emily Whiting

TO BE FIRST OFFERED: Sem./Year: Spring / 2019

SHORT TITLE: The “short title” appears in the course inventory, on the Link University Class Schedule, and on student transcripts and must be 15 characters maximum including spaces. It should be as clear as possible.

COURSE DESCRIPTION: This is the description that appears in the CAS and/or GRS Bulletin and The Link. It is the first guide that students have as to what the course is about. The description can contain no more than 40 words.

- Introduces 3D printing technology and computational methods for creating physical prototypes from geometric models. Student-led paper presentations cover research from prominent Computer Graphics and Human Computer Interaction conferences. Culminates in a design project involving a computational component and physical prototyping.

PREREQUISITES/COREQUISITES: Indicate “None” or list all elements of the prerequisites/corequisites, clearly indicating “AND” or “OR” where appropriate. Here are three examples: “Junior standing or CAS ZN300 or consent of instructor”; “CAS ZN108 and CAS ZN203 and CAS PQ206; or consent of instructor”; “For SED students only.”

1. State the prerequisites and/or corequisites:
   - Prereqs: CS 112, and CS 132 or MA 242, CS 480/680 recommended

2. Explain the need for these prerequisites and/or corequisites:
   - CS 112 – Students must have working knowledge of programming and data structures
   - CS 132 or MA 242 – Students must have familiarity with linear algebra
   - CS 480 – Familiarity in Computer Graphics recommended for students but not required
CREDITS: (check one)

☐ Half course: 2 credits  ☐ Variable: Please describe.
☒ Full course: 4 credits  ☐ Other: Please describe.

Provide a rationale for this number of credits, bearing in mind that for a CAS or GRS course to carry 4 credits, 1) it must normally be scheduled to meet at least 150 minutes/week, AND 2) combined instruction and assignments, as detailed in the attached course syllabus, must anticipate at least 12 total hours/week of student effort to achieve course objectives.

• Course follows normal patterns outlined above for a 4.0 credit course.

DIVISIONAL STUDIES CREDIT NOTE: If this course intended to fulfill CAS Divisional Studies requirements, do not use this proposal form. The course must be proposed through the BU Hub process via CourseLeaf. Refer to http://www.bu.edu/cas/proposing-cas-courses-for-the-bu-hub/ for instructions.

HOW FREQUENTLY WILL THE COURSE BE OFFERED?

☐ Every semester  ☐ Once a year, fall  ☐ Once a year, spring  ☐ Every other year  ☐ Other: Explain:

NEED FOR THE COURSE: Explain the need for the course and its intended impact. How will it strengthen your overall curriculum? Will it be required or fulfill a requirement for degrees/majors/minors offered by your department/program or for degrees in other departments/school/colleges? Which students are most likely to be served by this course? How will it contribute to program learning outcomes for those students? If you see the course as being of “possible” or “likely” interest to students in another departments/program, please consult directly with colleagues in that unit. (You must attach appropriate cognate comments using cognate comment form if this course is intended to serve students in specific other programs. See FURTHER INFORMATION below about cognate comment.)

• This course is based on three successful offerings at Dartmouth College in Fall 2014, Spring 2016, and Fall 2016. Each offering had to be capped due to the high level of interest in the subject matter.
• This course adds a key element to the department’s curriculum in the area of Interactive Computing. The department currently offers CS 480/680 Introduction to Computer Graphics as the “core” Graphics course, which introduces the foundations for this course including 3D shape representations, geometric modeling, and visualization. The department also offers CS 580 Advanced Computer Graphics, which covers advanced topics in modeling, rendering and animation. The proposed course serves to extend these computational approaches into the domains of manufacturing and design. Students will gain practical experience with 3D printing technology and CNC machines through the design project. In parallel, lectures will review how rapid prototyping has opened new challenges in computational geometry, human-computer interaction, simulation, and other areas of Computer Science. Reading and critiquing research papers will aid in understanding the trajectory of innovation.
• Students will be encouraged to publish the outcomes of their projects as peer-reviewed conference papers and potentially continue their research as a Directed Study after the course concludes.
• The course will fulfill a “Group D” elective course for CS majors, serves as a potential elective for CS minors, and a possible “Applications” breadth course for CS Masters and PhD students. It may also be integrated into our Concentration in Computer Graphics, Games, and Animation. The course will
most likely serve CS undergraduate majors, with a substantial number of CS Masters and PhD students also taking the course. It is not intended to serve students in other programs, but it will likely be of interest to students in ENG or those studying design and architecture.

ENROLLMENT: How many undergraduate and/or graduate students do you expect to enroll in the initial offering of this course?

- 20-25 initially, then scaling in future offerings.

CROSS-LISTING: Is this course to be cross-listed or taught with another course? If so, specify. Chairs/directors of all cross-listing units must co-sign this proposal on the signature line below.

- No.

OVERLAP: Relationship to other courses in your program or others: Is there any significant overlap between this course and others offered by your department/program or by others? (You must attach appropriate cognate comments using cognate comment form if this course might be perceived as overlapping with courses in another department/program. See FURTHER INFORMATION below.)

- There is no significant overlap that we are aware of between this course and others both in our department or other departments.

FACILITIES AND EQUIPMENT: What, if any, are the new or special facilities or equipment needs of the course (e.g., laboratory, library, instructional technology, consumables)? Are currently available facilities, equipment, and other resources adequate for the proposed course? (NOTE: Approval of proposed course does not imply commitment to new resources to support the course on the part of CAS.)

- The course makes use of 3-D printing technology. Currently available facilities and equipment within the department are adequate for this course. Supplementary resources for 3-D printing will be available at EPIC: Engineering Product Innovation Center.

STAFFING: How will the staffing of this course, in terms of faculty and, where relevant, teaching fellows, affect staffing support for other courses? For example, are there other courses that will not be taught as often as now? Is the staffing of this course the result of recent or expected expansion of faculty? (NOTE: Approval of proposed course does not imply commitment to new resources to support the course on the part of CAS.)

- Creation of this course is the result of recent new faculty hiring in the department. The course will be taught annually by Assistant Professor Emily Whiting who joined the faculty in Summer 2017. The course content is closely aligned with the expertise of her research lab.
- The course will require Teaching Fellow support to staff lab sections and to scale the course to meet demand.

BUDGET AND COST: What, if any, are the other new budgetary needs or implications related to the start-up or continued offering of this course? If start-up or continuation of the course will entail costs not already discussed, identify them and how you expect to cover them. (NOTE: Approval of proposed course does not imply commitment to new resources to support the course on the part of CAS.)
• Costs include 3-D printer purchases and supplies. The funding for these expenses will come from departmental operating budgets used to support our educational expenses.

EXTERNAL PROGRAMS: If this course is being offered at an external program/campus, please provide a brief description of that program and attach a CV for the proposed instructor.

• N/A.
ADDITIONAL DOCUMENTS THAT MUST BE SUBMITTED FOR THIS PROPOSAL TO BE CONSIDERED:

- A complete week-by-week SYLLABUS with student learning objectives, readings, and assignments that reflects the specifications of the course described in this proposal; that is, appropriate level, credits, etc. (See guidelines on “Writing a Syllabus” on the Center for Teaching & Learning website.) A typical, effective syllabus template is provided here under “Curriculum Review & Modification”.

- Be sure that syllabus includes your expectations for academic honesty, with URL for pertinent undergraduate or GRS academic conduct code(s).

- Cognate comment from chairs or directors of relevant departments and/or programs. Use the form here under “Curriculum Review & Modification.” You can consult with Dean Joseph Bizup (CAS) at casuap@bu.edu or Dean Emily Barman (GRS) at eabarman@bu.edu to determine which departments or programs inside and outside of CAS/GRS would be appropriate.

DEPARTMENT CONTACT NAME & POSITION: Emily Whiting, Assistant Professor

DEPARTMENT CONTACT EMAIL & PHONE: 617-353-8919, whiting@bu.edu

Signature(s) required:

DEPARTMENT APPROVAL: Department Chair  Date

Other Department Chair(s) (required for cross-listed courses)  Date

revised 10/11/2017
CAS CS 581 COURSE INFORMATION

In this advanced level seminar course, you’ll learn about 3D printing technology and fundamental computational tools for creating physical prototypes from geometric models. In reading group style, we will explore the range of applications, such as furniture design, spinning toys, and sculpting. Paper selections will cover cutting-edge research from prominent Computer Graphics conferences including SIGGRAPH, UIST, and Eurographics. The coursework will culminate in a final project. In small teams, projects will be a focused study, involving a computational component and physical prototyping of the final results.

Prerequisites: This is an upper-level undergraduate/graduate course and requires the following skills:
- Working knowledge of programming and data structures (CAS CS 112, or equivalent)
- Familiarity with linear algebra (CAS CS 132 or MA 242, or equivalent)
- Recommended: Computer Graphics (CS 480/680, or equivalent)

Logistics:
- Tue/Thu 2:00 - 3:15pm
- Location: MCS B31
- Instructor: Emily Whiting <whiting@bu.edu> / office hours: Mon/Fri 2-3pm in MCS 295A
- TF: / office hours:
- Website: see Blackboard
- Piazza: piazza.com/bu/spring2018/cs591w1

Special Events:
- Tour of Autodesk Build Space
- Poster Session and Final Presentations: 3-hour session on last day of class

SCHEDULE

<table>
<thead>
<tr>
<th>WEEK</th>
<th>TOPIC</th>
</tr>
</thead>
</table>
| 1    | Lecture: Introduction to Computational Fabrication  
      | Due: Paper selections for reading group |
| 2    | Lecture: Solid Modeling / Tour of EPIC rapid prototyping resources  
      | Due: Safety quiz for EPIC |
| 3    | Lecture: 3D Printing technology: hardware technologies, materials  
      | In-class presentations on 3D Printing innovations in recent news |
| 4    | Guest Lecture: History of CAD and introduction to Onshape cloud-based CAD  
      | Paper session 1: Two student presentations with discussion items submitted before class  
      | Due: Voxelizer programming assignment / online CAD tutorial |
| 5    | Guest Demo Session: Introduction to Onshape Featurescript programming language  
      | Paper session 2  
      | Due: Paper discussion items / online Featurescript tutorial |
| 6    | (Monday Holiday / Tuesday class cancelled)  
      | Project session: In-class pitch presentations (individual) |
| 7  | Project session: In-class proposal presentations (team)  
    | Paper session 3  
    | Due: Paper discussion items |
| 8  | Lecture: 3D Printing software pipeline: support structures, slicing, path planning  
    | Paper session 4  
    | Due: Paper discussion items |
| 9  | Guest Lecture: TBD  
    | Paper session 5  
    | Due: Paper discussion items |
| 10 | Field trip to Autodesk BUILD Space  
    | Paper session 6  
    | Due: Paper discussion items |
| 11 | Project session: In-class midterm presentations (team) |
| 12 | Lecture: Kinematics of Mechanisms  
    | Paper session 7  
    | Due: Paper discussion items |
| 13 | Guest Lecture: 3D Printing medical applications  
    | Paper session 8  
    | Due: Paper discussion items |
| 14 | Paper session 9  
    | Project session: Meetings with groups  
    | Due: Paper discussion items |
| 15 | Project session: Final presentations, demos and poster session (3 hours, open to public) |

**PAPER READINGS**

The reading group is an opportunity to study and critique the state-of-the-art in fabrication research. We will be reading papers from the primary publication venues in computer graphics and human-computer-interaction including SIGGRAPH, SIGGRAPH Asia, CHI, UIST, and Transactions on Graphics. Presentations begin in the 4th week of the course, and continue weekly throughout the semester. Everyone is responsible for presenting one (1) paper in class. Each student is also required to read every paper and participate in discussions. Before each presentation students must submit a short piece of writing summarizing and commenting on the work.

- Stress Relief: Improving Structural Strength of 3D Printable Objects [Stava et al. SIGGRAPH 2012]
- Computational Thermoforming [Schuller et al. SIGGRAPH 2016]
- Chopper: Partitioning Models into 3D-Printable Parts [Luo et al. SIGGRAPH Asia 2012]
- Make It Stand: Balancing Shapes for 3D Fabrication [Prevost et al. SIGGRAPH 2013]
- WirePrint: 3D Printed Previews For Fast Prototyping [Mueller et al. UIST 2014]
- Architecture-Scale Human-Assisted Additive Manufacturing [Yoshida et al. SIGGRAPH 2015]
- Spin-It: Optimizing Moment of Inertia for Spinnable Objects [Bacher et al. SIGGRAPH 2014]
- faBrickation: Fast 3D printing of Functional Objects by Integrating Construction Kit Building Blocks [Mueller et al. CHI 2014]
- Buoyancy Optimization for Computational Fabrication [Wang et al. Eurographics 2016]
- Designing Inflatable Structures [Skouras et al. SIGGRAPH 2014]
- AirCode: Unobtrusive Physical Tags for Digital Fabrication [Li et al. UIST 2017]
- Digital Mechanical Metamaterials [Ion et al. CHI 2017]
- Designing Structurally-Sound Ornamental Curve Networks [Zehnder et al. SIGGRAPH 2016]
- Perceptual Models of Preference in 3D Printing Direction [Zhang et al. SIGGRAPH Asia 2015]
- Cost-effective Printing of 3D Objects with Skin-Frame Structures [Wang et al. SIGGRAPH Asia 2013]
- Patching Physical Objects [Mueller et al. UIST 2015]
• 3D-Printing of Non-Assembly, Articulated Models [Cali et al. SIGGRAPH Asia 2012]
• Fabrication-aware Design with Intersecting Planar Pieces [Schwartzburg et al. Eurographics 2013]

POLICIES

Grading: The main graded work for the course is the design project and reading group. The project is team-based and all team members will receive the same grade on the project deliverables (except for the initial pitch which is individual). It is the responsibility of the group to ensure workload is distributed fairly among team members. There will also be several small assignments including programming, class presentations, and other activities. Given the seminar nature of this course, attendance at all class meetings and events is mandatory (unless otherwise noted) and a participation component is included in the final grade. The grade breakdown is as follows:

Design Project (50%)
• Pitch 2%
• Proposal 8%
• Midterm 15%
• Final 30%

Reading Group (40%)
• Paper selection 1%
• Paper Presentation 20%
• Discussions & Participation 19%

Assignments (10%)
• Programming assignment 7%
• Mini-assignments (Fabrication in the news, tutorials, lab safety test) 3%

Late Policy: Late work will incur the following penalties: 20% off per day, up to 2 days.

Academic Honesty Policy: Academic honesty is taken very seriously. Cheating, plagiarism and other misconduct may be subject to grading penalties up to failing the course. Students enrolled in the course are responsible for familiarizing themselves with the detailed BU Academic Conduct Code. In particular, plagiarism is defined as follows and applies to all written materials, presentations, and software, including material found online:

III.B. Plagiarism: Representing the work of another as one’s own. Plagiarism includes but is not limited to the following: copying the answers of another student on an examination, copying or restating the work or ideas of another person or persons in any oral or written work (printed or electronic) without citing the appropriate source, and collaborating with someone else in an academic endeavor without acknowledging his or her contribution. Plagiarism can consist of acts of commission-appropriating the words or ideas of another-or omission failing to acknowledge/document/credit the source or creator of words or ideas (see below for a detailed definition of plagiarism). It also includes colluding with someone else in an academic endeavor without acknowledging his or her contribution, using audio or video footage that comes from another source (including work done by another student) without permission and acknowledgement of that source.

Collaboration is an integral part of this course for the design project. Students must uphold standards of academic conduct for all materials presented in experimental results and reports, and follow the rules governing teamwork. Violations include but are not limited to:

III.C. Misrepresentation or falsification of data presented for surveys, experiments, reports, etc., which includes but is not limited to: citing authors that do not exist; citing interviews that never took place, or field work that was not completed.

III.K. Violation of the rules governing teamwork. Unless the instructor of a course otherwise specifically provides instructions to the contrary, the following rules apply to teamwork: 1. No team member shall intentionally restrict or inhibit another team member’s access to team meetings, team work-in-progress, or other team activities without the express authorization of the instructor. 2. All team members shall be held
responsible for the content of all teamwork submitted for evaluation as if each team member had individually submitted the entire work product of their team as their own work.

Religious Observance: Students are permitted to be absent from class, including classes involving examinations, labs, excursions, and other special events, for purposes of religious observance. In-class, take-home and lab assignments, and other work shall be made up in consultation with the student’s instructors. More details on BU’s religious observance policy are available here.