Application

Name: Brian Giffin

Student Data

First name	Middle name	Last name
Brian	**Doran**	**Giffin**

Previous names (ex: maiden name)

E-mail

bdgiffin@ucdavis.edu

Citizenship

Country of Birth: **United States of America**

U.S. Citizen: **Yes**

If no,

- *Country of Citizenship:*
- *Permanent Resident Alien:* **-----**

If yes,

- *PRA Number:*
- *Port of Entry:*

Name: Brian Giffin

Current Mailing Address

Street address 1

836B Adams Terrace

Street address 2

City	*State*	*Zip code*
Davis	**CA**	**95616**

Home phone	*Cell phone*	*Work phone*
n/a	**(916)-770-6105**	**n/a**

Address effective through (m/d/y): **6/20/2015**

After this date, all correspondence will be sent to the permanent address listed below unless otherwise requested.

Notify the Krell Institute if your address changes after the application has been submitted.

Permanent Address

Street address

1900 S. Cirby Way, Apartment # 79

City	*State*	*Zip code*
Roseville	**CA**	**95661**

Phone

(916)-770-6105

Name: Brian Giffin

Graduate Record Examination

Verification of these scores is required. (Note: Official Graduate Record Examination (GRE) Scores must be sent directly by the Educational Testing Service to the Krell Institute/DOE Computational Science Graduate Fellowship program. The Krell Institute's Institution Code is **6343** and the department code is **5199**)

Your name as it appears on your GRE record:	**Brian D Giffin**
Date test taken/to be taken:	**11/14/2012**

GRE Test Results

			Reported from ETS	
Examination	***Score***	***Percentile(%)***	***Score***	***Percentile(%)***
Verbal	159	81	159	81
Quantitative	163	86	163	86
Analytical or Analytical Writing	4.5	80	4.5	80

References

List at least three persons familiar with your academic preparation and your technical abilities. Please have these individuals mail the reference forms directly to Krell Institute.

	Title	***First name***	***Last name***	***Institution***	***E-mail***	***Status***
1.	**Dr.**	**Joseph**	**Jung**	**Sandia National Laboratories**	**jjung@sandia.gov**	**Submitted**
2.	**Dr.**	**Mark**	**Rashid**	**University of California, Davis**	**mmrashid@ucdavis.edu**	**Submitted**
3.	**Dr.**	**N.**	**Sukumar**	**University of California, Davis**	**nsukumar@ucdavis.edu**	**Submitted**
4.	**Dr.**	**John**	**Bolander**	**University of California, Davis**	**jebolander@ucdavis.edu**	**Submitted**

Name: Brian Giffin

Academic Status

Current Academic Status: **First Year Doctoral Student**

Have you completed any academic credit towards your computational science/engineering doctoral degree? **Yes**

If yes, how many terms have you completed? (exclude summer) **4 Quarter**

Official transcripts from every listed institution are a required component of the application including your Fall 2014 transcript, if applicable. Please see the instructions for more information on where to send the transcripts.

Doctoral Institution (Institution where you plan on completing your computational science and engineering doctorate or first choice doctoral university):

Institution	*Start Date*	*Expected End Date*	*Department*	*Academic Discipline*	*GPA*	*Degree*
University of California, Davis	01/2015	06/2017	Civil & Environmental Engineering	Computational Solid Mechanics	4.00	PhD

Department Chair at Doctoral Institution:

First Name	*Last Name*	*Email*
Sashi	Kunnath	skkunnath@ucdavis.edu

Other Doctoral Institution Choices (Answer only if not currently at doctoral institution)

			Department Chair Information		
Institution	*Department*	*Academic Discipline*	*First Name*	*Last Name*	*Email*

Higher Educational History (All university/colleges attended and degrees obtained with the exception of the doctoral degree listed above):

Institution	***Start Date***	***End Date Expected or Actual***	***Department***	***Academic Discipline***	***Degree***	***GPA***
University of California, Davis	09/2013	12/2014	Civil & Environmental Engineering	Structural Mechanics	Masters	4.00
University of California, Davis	09/2009	06/2013	Civil & Environmental Engineering	Civil Engineering	Bachelors	3.98
					None	
					None	
					None	

Name: Brian Giffin

Graduate Advisor

The graduate advisor is the person from the preferred institution **who views and approves the Program of Study.**

First Name	*Last Name*
Mark	**Rashid**

Institution	*Title (Dr., Ms., Professor, ...)*
University of California, Davis	**Professor**

E-mail

mmrashid@ucdavis.edu

Address 1

Department of Civil and Environmental Engineering

Address 2

University of California, One Shields Avenue

City	*State*	*Zip Code*
Davis	**CA**	**95616**

Telephone	*Fax*
(530)-752-7013	

Name: Brian Giffin

Program of Study

Listed are the courses in science and engineering, applied mathematics, and computer science that you agreed to take on your proposed Program of Study.

University: University of California, Davis

Course number	Course Title	Credit hours	Term and Year	Grade	Academic Level
Science/Engineering					
ECI 205	Continuum Mechanics	3.0Q	Winter 2015		G
MAE 222	Advanced Dynamics	4.0Q	Fall 2017		G
MAE 250C	Mechanical Performance of Materials	4.0Q	Spring 2016		G
Mathematics and Statistics					
MAT 201A	Analysis	4.0Q	Fall 2015		G
MAT 226B	Numerical Methods: Large-Scale Matrix Computations	4.0Q	Winter 2016		G
MAT 228B	Numerical Solution of Differential Equations	4.0Q	Winter 2015		G
Computer Science					
ECS 222A	Design and Analysis of Algorithms	4.0Q	Fall 2016		G
ECS 223	Parallel Algorithms	4.0Q	Spring 2017		G
ECS 231	Large-Scale Scientific Computation	4.0Q	Winter 2017		G

I have read this program of study and affirm that, in my opinion, it satisfies the fellowship program requirements. This POS has been approved by my advisor, **Mark Rashid**, and I understand that, if offered a fellowship, my advisor and I are required to sign this page and send it to the Krell Institute.

Student's signature ___________________________ Date _______________

Graduate Advisor: **Mark Rashid**
Graduate Advisor's Institute: **University of California, Davis**
Graduate Advisor signature ___________________________ Date _______________

Krell Institute (Office use only) _________________________________

Krell Institute, Attn: DOE CSGF Coordinator
1609 Golden Aspen Drive, Suite 101, Ames, IA 50010
Phone: 515-956-3696, Fax: 515-956-3699, csgf@krellinst.org

Name: Brian Giffin

Course Description

ECI 205: Continuum Mechanics

Tensor formulation of the field equations for continuum mechanics, including large deformation effects. Invariance and symmetry requirements. Introduction to nonlinear thermoelasticity and thermodynamics. Solution of three-dimensional problems.

MAE 222: Advanced Dynamics

Dynamics of particles, rigid bodies and distributed systems with engineering applications; generalized coordinates; Hamilton's principle; Lagrange's equations; Hamilton-Jacobi theory; modal dynamics orthogonality; wave dynamics; dispersion.

MAE 250C: Mechanical Performance of Materials

Occurrence, mechanisms, and prediction of fatigue and fracture phenomenon. Use of stress and strain to predict crack initiation. Use of fracture mechanics to predict failure and crack propagation. Effects of stress concentration, manufacturing, load sequence, irregular loading, and multi-axial loading.

MAT 201A: Analysis

Metric and normed spaces. Continuous functions. Topological, Hilbert, and Banach spaces. Fourier series. Spectrum of bounded and compact linear operators. Linear differential operators and Green's functions. Distributions. Fourier transform. Measure theory. Lp and Sobolev spaces. Differential calculus and variational methods.

MAT 226B: Numerical Methods: Large-Scale Matrix Computations

Numerical methods for large-scale matrix computations, including direct and iterative methods for the solution of linear systems, the computation of eigenvalues and singular values, the solution of least-squares problems, matrix compression, methods for the solution of linear programs.

MAT 228B: Numerical Solution of Differential Equations

Numerical solution of elliptic PDEs using Geometric Multigrid, Conjugate Gradient Method, and Multigrid Preconditioned Conjugate Gradient.

ECS 222A: Design and Analysis of Algorithms

Techniques for designing efficient algorithms, analyzing their complexity and applying these algorithms to a broad range of applications. Methods for recognizing and dealing with difficult problems.

ECS 223: Parallel Algorithms

Prerequisite: course 222A. Models of parallel computer systems including PRAMs, loosely coupled systems and interconnection networks. Parallel algorithms for classical problems and general techniques for their design and analysis. Proving lower bounds on parallel computation in several settings.

ECS 231: Large-Scale Scientific Computation

Algorithms and techniques for large-scale scientific computation, including basics for high performance computing, iterative methods, discrete approximation, fast Fourier transform, Poisson solvers, particle methods, spectral graph partition and its applications.

Name: Brian Giffin

Research Statements

This information is vital to the overall evaluation of your application.

Program of Study

Please describe how you expect that the courses listed in your planned program of study will contribute to your own research and will promote the development of a strong interdisciplinary background in computational science. Discuss why you chose these courses.

To provide some context: my area of interest with respect to computational science falls under the category of computational solid mechanics. My intended career path is to pursue the development of high performance multiphysics finite element codes, most likely at a national laboratory.

With regard to my selection of courses for engineering/sciences, I have already taken all of the solid mechanics courses offered at UC Davis, with the exception of continuum mechanics (which I am currently enrolled in.) To broaden my engineering background, I decided to pursue some of the offerings from the Mechanical and Aerospace Department. My time at Sandia informed me of some of the ongoing challenges within computational solid mechanics, particularly: fracture, and contact. For this reason, I chose to pursue courses in fracture mechanics (MAE250C), and advanced dynamics (MAE222).

My time at Sandia also impressed upon me the importance of writing scalable code. It is one thing to write an efficient serial algorithm, but wholly another to design, implement, and debug a parallel code. For this reason, I sought out computer science courses that would not only improve my knowledge of algorithmic design (ECS222A), but also inform me of the principles behind parallelization (ECS223, ECS231). Though not listed on my program of study, I also intend to take a course in computational geometry (ECS226) to better understanding finite element meshing.

For my own research, much of the theory of finite elements (and in particular, non-conforming methods), involves the exploitation of the appropriate function spaces (i.e. Sobolev spaces). To this end, I decided to pursue courses that would treat the principles of functional analysis (MAT201A-C). Additionally, since FEM typically involves the solution of large linear systems, and because there is a need for solving such systems efficiently (via parallelization), I chose a course that would cover these topics (MAT226B). It is also important that I gain a better perspective on finite difference methods, which have applications in other areas of coupled computational mechanics (e.g. fluid mechanics). For this reason, I am currently pursuing a series of courses on this subject (MAT228A-C).

Research Using High-Performance Computing and/or Large Data Analysis

In your area of interest, what new science or engineering could be catalyzed by high performance computing and the new methodologies it enables (e.g., large data analysis and management, massive multiphysics simulation, agent-based models, etc.)? Why do you think this is the case?

What are the HPC challenges that need to be addressed to make this advancement?

With regard to the application of finite elements in science and engineering, I came upon two key observations: first, that the setup of detailed multiphysics simulations currently places an unreasonable modeling burden upon analysts. And second, that the current state of computing makes such large-scale computations infeasible in most applications. As a result, much of the potential benefit that could be gained from the widespread use of these simulation technologies is lost. To make FEM more accessible to scientists and engineers, there is much work to be done in the area of computational mechanics to both streamline/automate the modeling process, and to improve the efficiency and performance of the simulations.

Particularly, my time at Sandia informed me of the difficulties encountered by the Navy in their efforts to model ship hulls using shell elements. Degenerating the geometry and creating an analysis-ready FE model for this purpose is burdensome, time-consuming, and prone to human error. My research intends to pursue advanced formulations that are effective in arbitrarily thin structural configurations in an effort to alleviate the aforementioned issues. Likewise, polyhedral elements--a topic intimately related to my research--could enable fast automatic mesh generation for virtually arbitrary (including very thin) geometries. Besides accelerating the modeling process, this could have applications in areas such as topology optimization, and by extension, additive manufacturing.

If the meshing problem can be overcome, a vast number of multiphysics modeling opportunities could be made more accessible. The main limitation would then be the computational cost of the simulations. This is where the need for methods development in the context of high performance computing comes into the picture. Oftentimes, new finite element methodologies consider parallelization as an afterthought, and not as a main concern. However, for large-scale simulations, the code necessarily must be scalable. To this end, my goals are set on developing finite element methodologies and algorithms in my research that explicitly consider the role of parallelization as an organic element of the overall capability.

Field of Interest and the Role of Computational Science

Please discuss the experiences that have motivated you to pursue both computational science and your field of interest.

During my undergraduate career, I had the opportunity to pursue various engineering design challenges. However, I became more enthralled by the notion of developing engineering tools, as a means for supporting the actual practice of engineering. Particularly, I reveled in the use of automation to expedite otherwise tedious design tasks.

I was first exposed to computational solid mechanics during my first internship at Sandia National Laboratories, where I was introduced to particle methods. From this experience, I began to appreciate the possible design benefits that finite element methods development could provide for all manner of engineering disciplines. Afterwards, I was convinced that

the future of engineering lay with the more extensive use of simulation technologies.

I chose to pursue a Master's degree in structural mechanics, with my project focusing on the development of a technique for modeling hydraulic fracture. In the process, I gained an intimate familiarity with finite elements, and developed a good rapport with my advisor (Dr. Mark Rashid). But as much as I had learned, it became clear to me that the realm of FEM was a much deeper field than I had first imagined. To enhance my command of the subject, I resolved to pursue a Ph.D. in computational solid mechanics. My research will likely incorporate aspects of polyhedral finite elements for use in a thin continuum element formulation.

A year after my first stay at Sandia, I was invited back for a second internship, this time working with the SIERRA Solid Mechanics code development team. Here, I gained a greater exposure to--and appreciation for--the role of high-performance computing in finite elements. In a practical setting, I seized the opportunity to learn and use C++ to help implement a polyhedral finite element capability within SIERRA. I also became aware of the current challenges facing finite element code development: XFEM based fracture, efficiency of contact algorithms, coupled multiphysics problems, shell-to-shell tying methods, polyhedral meshing and element formulation, SIMD vectorization, GPU acceleration, and next-generation platform development. I will be returning to Sandia this coming summer to resume my work.

List of publications

Please include a list of publications authored or co-authored by the applicant.

Though we did not pursue publication, I did produce a report for my Master's project entitled ``Applied Poromechanics for Hydraulic Fracture Simulation,'' for which I was the main author. The report itself details the development of a finite element implementation for coupled poromechanics that makes use of a simple damage mechanics scheme to emulate hydraulically driven fracture. The work was conducted in collaboration with Lawrence Livermore National Laboratory, with the actual implementation of the aforementioned methodology performed within the ``GEOS-CORE'' finite element code. I would be happy to present a copy of the report, upon request.

Name: Brian Giffin

Other Planned Courses

Listed are the other courses you plan to take that you believe are particularly pertinent to your proposed or current research in the areas of Mathematics, Science and Engineering, and Computer Science.

Course number	Course Title	Credit hours	Term and Year	Grade	Academic Level
Science/Engineering					
MAT 201B	Analysis	4.0Q	Winter 2016		G
MAT 201C	Analysis	4.0Q	Spring 2016		G
Computer Science					
ECS 122A	Algorithm Design and Analysis	4.0Q	Spring 2016		G
ECS 226	Computational Geometry	4.0Q	Winter 2017		G

Name: Brian Giffin

Course Description

MAT 201B: Analysis

Metric and normed spaces. Continuous functions. Topological, Hilbert, and Banach spaces. Fourier series. Spectrum of bounded and compact linear operators. Linear differential operators and Green's functions. Distributions. Fourier transform. Measure theory. Lp and Sobolev spaces. Differential calculus and variational methods.

MAT 201C: Analysis

Metric and normed spaces. Continuous functions. Topological, Hilbert, and Banach spaces. Fourier series. Spectrum of bounded and compact linear operators. Linear differential operators and Green's functions. Distributions. Fourier transform. Measure theory. Lp and Sobolev spaces. Differential calculus and variational methods.

ECS 122A: Algorithm Design and Analysis

Complexity of algorithms, bounds on complexity, algorithms for searching, sorting, pattern matching, graph manipulation, combinatorial problems, randomized algorithms, introduction to NP-complete problems.

ECS 226: Computational Geometry

Mathematics of unstructured data. Algorithms for data structures such as Voronoi diagrams, oct-trees, and arrangements. Applications in computer graphics, concentrating on problems in three-dimensions.

Name: Brian Giffin

Completed Courses

Please list up to six courses you have completed that are particularly pertinent to your proposed or current research in the areas of Mathematics, Science and Engineering, and Computer Science. Please do not list entry level science/engineering or mathematics courses like Calculus I.

Course number	Course Title	Credit hours	Term and Year	Grade	Academic Level
ECI 201	Introduction to Theory of Elasticity	4.0Q	Fall 2013	A+	G
ECI 203	Inelastic Behavior of Solids	3.0Q	Winter 2014	A	G
ECI 212A	Finite Element Procedures in Applied Mechanics	4.0Q	Winter 2014	A	G
ECI 212B	Finite Elements: Applications to Linear and Nonlinear Structural Mechanics Problems	4.0Q	Spring 2014	A+	G
ECI 289E	Advanced Topics in Finite Element Method	2.0Q	Fall 2014	A+	G
MAT 228A	Numerical Solution of Differential Equations	4.0Q	Fall 2014	A	G

Name: Brian Giffin

Course Description

ECI 201: Introduction to Theory of Elasticity

Fundamental equations of elasticity in three dimensions; plane stress and plane strain; flexture and torsion of bars of various shapes. Introduction to variational and approximate methods.

ECI 203: Inelastic Behavior of Solids

undamentals of theories of plasticity, viscoelasticity and viscoplasticity for solids. Macroscopic constitutive modelling for engineering materials, e.g., metals, polymers, soils, etc., and microscopic motivation.

ECI 212A: Finite Element Procedures in Applied Mechanics

The focus in this course is to provide students a sound understanding o the variational basis and tools required to develop Galerkin finite elements for linear boundary-value problems in applied mechanics. Students will be introduced to good programming practices for finite elements, and through computer assignments, they will program finite elements for the purpose of computer simulations in structural and solid mechanics.

ECI 212B: Finite Elements: Applications to Linear and Nonlinear Structural Mechanics Problems

Application to linear and nonlinear structural mechanics problems. Linear elasticity, weak form, and finite element approximation. Incompressible media problems. Non-linear problems with material nonlinearity.

ECI 289E: Advanced Topics in Finite Element Method

A more thorough treatment of nonlinearity than was included in 212B, including finite-deformation kinematics, inelastic constitutive update, contact enforcement, linear equation solution, non-conforming methods, approximation theory and convergence of the FEM.

MAT 228A: Numerical Solution of Differential Equations

The course will cover conservative finite difference methods for compressible fluid flow, and projection methods for incompressible flow. The course will emphasize the relationship between the underlying mathematical description of the fluid dynamics and the numerical methods, and design principles based on a combination of systematic analysis of subproblems / model problems, physical reasoning, and numerical experiment.

Name: Brian Giffin

Laboratory and Research Experience/Other Employment

Begin with current or most recent employment. Please include employer, dates employment started and ended, position, and nature of work.

University of California Davis, 1/2015-Present, ECI212A (Introduction to Finite Elements) Reader, Assisting with grading coursework for graduate level class on finite elements.

University of California Davis (and in collaboration with Lawrence Livermore National Laboratory), 2014 (excluding summer), Graduate Student Researcher, Collaborated with LLNL to develop and implement a new methodology for modeling hydraulic fracturing in the ``GEOS-CORE'' finite element code (conducted as part of Master's project.)

Sandia National Laboratories, Summer 2014, Graduate Student Intern, Code development within the ``SIERRA'' code implementing polyhedral finite element capabilities.

University of California Davis, 9/2013-12/2013, ECI003 (Introduction to Civil Engineering) Teaching Assistant, Lead laboratory sessions for undergraduate Civil Engineering course.

Sandia National Laboratories, Summer 2013, Student Intern, Performed verification testing for new implementation of Reproducing Kernal Particle Method (RKPM) in the ``SIERRA'' finite element code.

California Department of Transportation, 7/2012-6/2013, Student Intern, Assisted with routine bridge inspections, corrected as-built plans, prepared plans and quantities, and performed load ratings for California bridges

Programming Languages and Models

List (four at most) the programming languages and programming models with which you have experience.

Programming Languages: C++, FORTRAN, VBA, and MATLAB

Programming Models: MPI, OpenMP

Academic Awards and Honors

Include undergraduate and graduate honors (if applicable).

Dean's List, University of California Davis, 2009-2013 (all quarters)

Recipient of the 2012 SEAOCC Student Scholarship

2013 Departmental Citation Award in the College of Civil Engineering

B.S. in Civil Engineering from UC Davis: Graduated with highest honors (GPA of 3.98)

M.S. in Structural Engineering & Mechanics from UC Davis: Graduated with GPA of 4.00

Extracurricular Activities

Include technical societies and service organizations.

UC Davis 2013 Steel Bridge (Student Competition) Team Captain (placed 3rd place nationally)

UC Davis ASCE Student Chapter - Activities Chair 2013

Name: Brian Giffin

Additional Comments

Aside from being the UC Davis 2013 Steel Bridge (Student Competition) Project Manager, I have since remained in contact with the team at UC Davis, acting as both an advisor/instructor and developer of new design tools. In particular, I invested personal time to provide the team with a series of video tutorials on structural design. I also conducted independent research on structural optimization techniques (including topology optimization,) ultimately implementing (using VBA) some of these methods in user-friendly design tools that could be easily used by current and future teams. Tasks that previously took weeks of tedious and error-prone work on the part of the designers now takes a matter of minutes, and all at the press of a few buttons. These tools helped contribute to the 2014 team's success last year, when we achieved first place in the national competition (ahead of MIT-2nd and UC Berkeley-3rd.)

This desire to exploit computational science for the purposes of facilitating engineering and scientific opportunities is very much in line with my intended path forward. I hope to continue to provide practitioners of all disciplines with computational tools that will help pave the way for future innovations.

Name: Brian Giffin

DOE CSGF and Other Fellowships

The information that you provide will allow us to target our advertising more effectively. This information is confidential and is not used in review of the fellowship application.

1. Have you applied to other fellowship programs?

- ☐ DOE NNSA SSGF
- ☐ NSF
- ☐ DOD
- ☐ University-sponsored Names of fellowships:
- ☐ Other Names of fellowships:

2. How did you find out about the program?

- ☐ DOE CSGF poster
- ☐ DEIXIS, DOE CSGF annual publication
- ☐ Attended DOE CSGF talk
- ☐ Advertisement Name the source:
- Word of mouth from
  - ☐ faculty
  - ☑ student
  - ☐ administrator
- ☐ Laboratory staff
- ☐ Institutional announcement
- ☐ Conference or meeting Name:
- ☐ World Wide Web List URL:
- ☐ Other Explain:

Applicant Demographics

Applicant data is important in assessing the effectiveness of our efforts to solicit applications from a diverse population. Providing the information on this form is voluntary; omission of information will not affect any decision about your application. We appreciate your cooperation.

Race:	**Caucasian**
Gender:	**Male**
Physical/mental disability:	**No**