Purdue's Engineer of 2020
Seed Grant Funding for 2008-2009
Purdue University

Development and Assessment of "Ethics in Engineering Practice": A New Technical Support Elective

Target Attribute(s) to be studied/implemented: **Acting with high ethical standards in the global, social, intellectual and technological context**

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Development and Assessment of "Ethics in Engineering Practice": A New Technical Support Elective

The primary mission of the College of Engineering is to educate the next generation of engineering leaders from across the United States and abroad and to prepare them for work in technical fields. We do a superior job of imparting technical knowledge to our students, as evidenced by employers' interest in our students[1] and consistently high rankings by our peers and national news magazines. However, while technical competence is necessary, it is not a sufficient condition for the engineer of 2020 to be successful as noted in a recent NAE document,[2] and as acted upon recently in the Schools of Engineering.[3] There are other attributes that also must be present in our students if Purdue is to continue as a world leader in undergraduate education. Within the engineering and scientific community, it would be difficult to diminish the importance of acting with high ethical standards in global, social, intellectual and technological contexts. When this attribute is intrinsic in engineers and scientific personnel we rarely take note, but when it is absent and ethical standards break down, the world notices.

In recent years, there have been many well-documented engineering failures, including the losses of the *Challenger* and the *Columbia*, the Kansas City Hyatt Regency skywalk collapse, and the Exxon Valdez oil spill, as well as several high-profile cases of academic and scientific dishonesty in research. While the circumstances for each example are different, the underlying theme of each is that an individual or group of company employees was faced with ethical dilemmas in the performance of their jobs. Poor choices made in each of these cases had substantial impact on many people and have been the subject of significant public scrutiny. James Kroll, Head of Administrative Investigations in the Office of Inspector General at the National Science Foundation, estimates that between 2003-2008 the number of substantial ethics inquiries has increased from 3 per year to 37 per year.[4] These, he said, are "serious investigations where there are breeches of conduct regarding a NSF grant." The National Academy of Engineers has even developed a fairly comprehensive website to educate engineers about this issue.[5] According to a 1999 article by Stephan, nearly three-quarters of the engineering programs in the U.S. allow at least some students to graduate without taking a course whose catalog description mentions ethics.[6] The Schools of Engineering at Purdue University fall into this category.[a]

To meet the requirements for the engineer of 2020 and to address the need for formal training in ethics, we propose to develop a semester long course that will present ethics to our engineering undergraduates. *Our objective is to demonstrate that exposure and involvement in an ethics course specifically designed for engineers can mature the moral reasoning skills of those students who participate.* The proposed course would:

I. Present and discuss common ethical theories and applications
II. Investigate engineering-based case studies (Faculty-led case study investigations)
III. Teach students how to investigate and apply their knowledge to real situations (Student-led case studies and analysis)

In designing our course, we drew upon the observations of Haws[7] in his meta-analysis of 42 papers presented from 1996-1999 at American Society for Engineering Education (ASEE) conferences. Each of the papers he analyzed treated engineering ethics as a coherent educational objective. He noted six pedagogical approaches to teaching this class, including discussion of the professional engineer's code of ethics, humanist readings, theoretical grounding, ethical heuristics, case studies, and service learning. We use three of these approaches in the proposed class. Section I will ground the students in ethical theory. Haws[7] noted in his article that not grounding students in ethical theory is "probably the greatest single

[a] Note that there are several course available on campus that contain a short ethics unit, including CE 394 and MSE 430. ME 492, *Technology and Values*, examines the role of technology in society rather than consideration of ethics on a personal scale, as is being proposed here.

weakness in engineering ethics instruction." In this first section we will also present and discuss the engineer's code of ethics in relation to these ethical theories. The remaining part of the course will utilize faculty-led (Section II) and student-led case studies (Section III) to continue to mature their moral reasoning skills.

We envision a 3-hr technical support elective that any engineering major at the junior or senior level can take as part of his/her plan of study. In our course design, sections II and III will be broad enough to appeal to all engineering majors. We will also invite additional lecturers to address key issues including bioethics, patent law, engineering and public policy, and research on human subjects. The following pages will discuss each of these key course components in greater detail. The remainder of the proposal will then discuss assessment and future plans for the course.

I. Present and Discuss Common Ethical Theories

When teaching a technical course, we would never consider giving our students important equations and say, "Don't worry about understanding them; just use them and you will get the right answer." But we effectively do that to students when we tell them to read a company or professional society code of ethics and then say "make the right choice" without providing an understanding of ethical theories on which these codes are based. In frequent conversations with undergraduates in our school, it clear that they have little understanding of the rationale behind what is considered ethical behavior and we assume that is the case with students throughout the college. However, students in all engineering disciplines make ethical decisions many times each day. While some of these decisions have little impact, decisions made when they begin their first job and begin to rise through the ranks of a company, as many of our graduates do, can have a very significant impact. We do our students a great disservice when we do not provide a coherent view of ethical theory in which they can make these important decisions. The first 8 weeks of this course will provide this understanding.

Drawing upon our 11 years of combined experience teaching a shortened ethics unit in our senior design course (MSE 430), we will expand this section to provide a more complete understanding of ethical theory. We will begin this section by posing the following questions: "Why study ethics in the engineering discipline?" and "What elements should an ethical theory consider?" To lead the students to think about the answers to these questions, we use various scenarios, like the one below, as the basis for discussion.

> "You run a small consulting company and need an expert who can perform X-ray diffraction experiments. You look through 50 resumes and find one for a student that has XRD experience. The new employee is hired, but after a week it is clear that this person lied on their resume. The employee's responses include: (i) 'Everyone lies on their resume' (ii) 'I have a wife and kids who are hungry – I really need this job,' and (iii) 'I could learn if given the opportunity.' What do you do?"

In our experience in MSE 430, the undergraduates find these sorts of scenarios very engaging and the resulting discussions help flesh out their assumptions and beliefs regarding these matters.

Once we have the students thinking in an organized way about how they make ethical decisions, we will move to an explanation of a variety of systems used to make ethical decisions. We will study the three basic ethical systems: consequentialist, principled, and virtue-based ethics. *Consequentialist* ethics asks the question, "What path produces the best results?" Consequentialist ethical theory includes discussions of Ethical Egoism, popularized by Ayn Rand, and Utilitarianism, first proposed systematically by Jeremy Bentham in the 18th and 19th centuries. A presentation of *principled* ethics will follow, with an emphasis on Immanuel Kant. Principled ethics asks the question "What are my duties in these circumstances?" The final major ethical theory to be discussed is *virtue-based* ethics, a system that has made a major comeback in the past 10-15 years due to an influential book written by Alasdair MacIntyre[8], although it has its origins in Greek philosophy.[9] Virtue-based ethics asks the question, "Who should I become and what virtues should I develop?" As we previously stated, understanding ethical theories provides the basis for making good ethical decisions and provides the students with a rational approach to ethical issues. There are several standard ethics textbooks[10,11,12,13] available and we will select one of these books as a text to guide our discussions.

For a MWF meeting format, we envision using Monday and Wednesday lectures to develop the theory. We will use Friday lectures to apply some of the issues to specific current topics by inviting specialists from other schools within Engineering and across the campus to give lectures. These special topics would include bioethics, patent law infringement, engineering public policy, and research on human subjects. Furthermore, we intend to invite Dr. J.T. Kroll, Head of Administrative Investigations at NSF, to give a special lecture on ethical violations within the context of academic research, specifically addressing falsification and fabrication of data and plagiarism. Prof. Trice spoke to him last year and he has indicated an interest in visiting Purdue.

We will end this section of the class with a discussion of the Code of Conduct for Engineers as developed by ABET, as well as codes developed by relevant professional societies. The codes will be presented in terms of specific ethical dilemmas they will inevitably face in engineering practice, such as resume writing and professional competence, whistle blowing, intellectual property, and plagiarism. Strategies for dealing with these issues will be discussed, including the kinds of questions an engineer should ask (either of himself or others) prior to making a choice.

II. Faculty-Led Case Study Investigations

After establishing a foundational understanding of ethical theory, we will move to present case studies of famous engineering failures. The purpose of this section is to immerse the students in engineering details and to evaluate the choices made by individuals in isolation and in the context of their corporate culture. The cases will be chosen to include failures that are generally regarded as ethical lapses, as well as those that are not viewed that way. We have chosen a text, "Engineering Ethics: An Industrial Perspective,"[14] as a resource for the main outline of these stories, and will supplement this book with original reports on these accidents.

One distinctive aspect of this course compared to an ethics course offered by a philosophy department is the technical content. Because the course will be populated by engineers, we will present the engineering details, taking the time to present the background information necessary to understand both the problem and the point(s) at which a poor path was chosen by the individual or corporation. In most cases, such technical information is vital to properly evaluate the choices made. For example, in the 1981 Kansas City Hyatt Regency Skywalk collapse, we will perform the statics and strength of materials analysis on the original and final designs in order to elucidate the magnitude of the error and to understand the responsibilities of those involved.

At least one of these case studies will focus on the role organizational culture play in ethical decisions. The theory for these studies is laid out in a book on the development of the Space Shuttle Main Engine[15], in which the authors detail how corporate and political culture can strongly affect the behavior of a group of individuals. Another example of corporate culture leading individuals into ethical swamps is shown in a documentary on the Enron debacle.[16] We will also use the famous experiments on people's reaction to authority by Stanley Milgram to inform our discussions about how corporate culture can negatively influence decisions that we make.[17] In all of these discussions, our goal is to get the students to apply the theories learned in Section I to these cases.

III. Collaborative Learning through Student-Led Case Studies and Analysis

While student involvement in the lectures in the first two parts of the course is required, the purpose of the last three weeks of the course is to have groups of 3-5 students conduct their own investigations of technical failures and to evaluate them in light of the ethical theory and the practical case studies we have presented. These 50-min student-led presentations/discussions are intended to bring together all the elements of the course in collaborative learning exercises. The goal is for the student groups to conduct a complete analysis of the problem, showing and analyzing both technical and ethical aspects, of the problem. This exercise will effectively be their comprehensive final exam.

Assessment of Student Learning and Application of Knowledge

At the recent Engineering 2020 Conference at Purdue, it was the consensus of the ethics callout group that measuring how the response (behavior) of students encountering an ethical dilemma after leaving the university is exceedingly challenging. Tracking the occurrence of such events would require a large intrusion into the lives of our alumni and gauging the effect of this course on their behavior would be next to impossible. Of course, this is not the type of assessment we do in any of our courses. The assessment for this course will follow the same pattern as other courses we teach, except that we will measure not only knowledge at the end of the course, but also the change in knowledge due to the course. We will endeavor to discover if the knowledge they have obtained through lectures, special presentations, their own presentations and analyses, and their interactions in class will aid in the development of ethics as a skill set that they can use effectively in academic or industrial environments. Thus, the following paragraphs will describe how we will measure and assess student learning in this area.

In terms of assessing the knowledge gained, we will use a written exam after Section I of the course to measure students' understanding of the basic ethical theories. One of the ways we will measure their understanding is to provide a short scenario and ask them to compare and contrast the response of, for example, a utilitarian ethicist and a virtue-based ethicist. We will measure how well they understand each of the major ethical theories via analysis of the exams and will supplement subsequent lectures as required. Section III of the proposed course, where the students lead a discussion and analysis of case studies, will be used in lieu of a final exam to assess how well they have integrated their knowledge of ethical theories and their understanding of the engineering sciences into a coherent approach to deal with an ethical dilemma.

We will measure the progress of moral reasoning skills using the Defining Issues Test (DIT) before and after completing the proposed class.[18] This test presents six moral dilemmas, followed by 12 issue statements. In a 1998 paper by Self et al.[19] they assessed student's moral reasoning using the DIT in a similar manner to that proposed here, and reported that statistical differences in reasoning skills before and after were measured. They concluded that the effect of teaching ethics in engineering can be "rigorously measured." We envision using DIT2, a later version of DIT with 5 updated dilemmas, as an assessment aid in this class to capture the maturation of these important ethics reasoning skills. This test takes about 40 minutes to complete, about the time of one lecture. Similar to Self et al., we will give the test at the beginning of the course and at the end. The test is available for purchase from the Center for the Study of Ethical Development at the University of Minnesota. The price for 80 DIT2 tests and their scoring is $148.00 and is represented in the budget. The Center provides means and standard deviations for the pre- and post-test results, and can isolate subgroups (male and female, or junior and senior standing) with t-testing to determine if there are statistical differences between subgroups. By comparing our classroom exams (both written and oral) with the DIT2 test, we will gain important insight on our ability to aid the students in developing an ethics skill set. Deficiencies will be met with a change in the course structure and/or content.

It is important to assess student perspectives on what they think they have learned. We will gain this information through an end-of-the semester questionnaire where we ask student's questions like, "As a result of taking this course, do you think that you are equipped with an approach to make ethical choices?" By comparing student perspectives to the results obtained from the DIT2, we will be able to gain a broader view of our objective to demonstrate that exposure and involvement in an ethics course can mature the moral reasoning skills of those students.

CLASS SUSTAINABILITY, DISSEMINATION, AND FUTURE RESEARCH EFFORTS

The course will be advertised through each engineering school on campus, via announcements to discipline specific engineering honor societies, and, where allowed, brief announcements at the beginning of junior level courses. This class should meet the requirements of a technical support elective and thus will be open to all engineering majors. Our goal will be to have a 40 student enrollment in the fall, with larger classes expected in ensuing years.

Results will be disseminated via reports and presentations to the 2020 committee that describe the strengths and weaknesses of the course that first year. We have also requested travel money to present our results at an ASEE conference. We will perform a full ABET-style assessment of the course as well. Meetings with interested school heads will also be offered. Note that through the development of this course we will have an on-going test bed with which to evaluate the teaching of ethics. This fact will position us to respond to future National Science Foundation calls for proposals.

Feedback from the evaluation committee of the last funding cycle suggested that stand-alone modules be developed that could be inserted into other senior capstone classes, thus increasing the impact of the proposed course. The PIs for this grant believe this to be a reasonable suggestion. Our sense, though, is that we want to teach the course at least one time before attempting to design the modules. One of the questions we will ask of ourselves is, “Can we really shrink a 15 week course into a shortened module that would have similar impact on the student’s ethical reasoning skills?” Part of the answer to this question will come from our effectiveness in the classroom as measured by the DIT2 test described above. If we are measuring a large impact from the 15 week course, which would indicate that we are effectively teaching the subject matter, we will seriously consider developing a module and assess its effectiveness using the same DIT2 test. If the DIT2 tests results at the end of a 15 week course show modest improvement of moral reasoning skills, we will focus on continuing to improve the course prior to consideration of developing a module.

B. Timeline and Implementation Strategy

Insert summary of your implementation strategy as well as a timeline that specifies major milestones for the project, a midpoint and an end date for its completion (~1/2 to 1 page)

Course Development: July 2009

1st Course Offering: Spring of 2010

Assessment: Pre-test in January of 2010, Post-test in April 2010, Assessment of Exam and Presentations

Reporting: ABET Analysis, Communication with 2020 Committee and Heads: May 2010

Course Refinement: June 2010

2nd Course Offering: Spring 2011 Academic Year

Assessment: Pre-test in January of 2011, Post-test in April 2011, additional assessment as required

Reporting: ABET Analysis, Communication with 2020 Committee and Heads: January – May 2011

C. Personnel Requirements
Please indicate the portion of FTE that each faculty member will dedicate to the project

Faculty member	Summer 09	Fall 09	Spring 10
Rodney Trice	26.85% of one month		100% of one month
Matthew Krane	26.85% of one month		100% of one month

D. Budget
The budget worksheet is provided to assist you in developing your budget. You may fill this out and paste it directly into your proposal.

	Grant funds requested		
Faculty/Staff Name:	% Time	Fringe Benefits	$$
Rodney Trice	26.85%/100%	5,201.00	18,924
Matthew Krane	26.85%/100%	5,202.00	18,927
Subtotal Faculty/Staff Funding		$	$

Graduate Students				
	Grant funds requested			
Type of position	% Time	Insurance + Fee Remit	Fringe Benefits	$$
None				
Subtotal Graduate Student Personnel		$ 0.00	$ 0.00	$ 0.00

Undergraduate Student Funding
Please indicate the student resources (funding and time) you are requesting from the grant for this project.

	Grant funds requested		
Type of position	Hrs/week	Fringe Benefits	$$
None			

Subtotal Undergraduate Student Personnel			

Equipment $ Software Funding *Please list all specialized equipment and software required for the project. (Do not include standard computer equipment and commonly-available software, e.g. Microsoft Office, Microsoft Windows). Mark whether any of the equipment or software is provided by the department. (Note that only 10% of the funds can be used to purchase equipment and it needs to be dedicated to the goals of the project.*	
Name of Equipment	Funds Requested
None	
Subtotal Equipment	$0.00
Name of Software	
None	
Subtotal Software	$0.00
Other miscellaneous items (Computer media, cables, etc)	
None	
Subtotal miscellaneous	$0.00
Other expenses	
Eighty DIT2 Tests & Scoring from Center for the Study of Ethical Development	148.00
Travel	2,000.00
Subtotal other expenses	$2,148.00

Total Amount Requested: $39,999

E. Budget Justification

Summer salary is requested for Profs. Trice and Krane (0.27 months) in July of 2009 (approximately 1 week) for the development of the new course. They will teach this course for the first time in January, 2010, because course conflicts within the MSE department prevent both instructors from offering the course in the fall of 2009. Thus, 1.0 months of academic year salary/per faculty member is requested for Spring 2010.

Budget is requested to purchase the DIT2 test that will be used to assess moral reasoning capabilities at the start and end of the semester. Travel funds are included as a means to share the results of this study at a national conference.

F. References

1. The job fair organized by PESC attracts the largest, and most discerning employers.
2. National Academy of Engineering, *The Engineer of 2020* (2004).
3. Purdue EFD 15-06, Adoption of the Purdue Engineer of 2020 Target Attributes.
4. J. T. Kroll, Office of the Inspector General at NSF, oral presentation at NSF-CMMI Grantees Conference, Knoxville, TN, January 8, 2008, and a phone call on January 25, 2008.
5. www.onlineethics.org/
6. Karl D. Stephan, "A Survey of Ethics-Related Instruction in U.S. Engineering Programs," J. Eng. Ed., **10** 459-64 (1999).
7. David Haws, "Ethics Instruction in Engineering Education: A (Mini) Meta-Analysis," J. Eng. Ed, 4 223-9 (2001).
8. A. MacIntyre, *After Virtue: A Study in Moral Theory*, 3rd Ed, University of Notre Dame Press (2007).
9. Aristotle, *The Nicomachean Ethics*, Penguin Classics (2003).
10. James Rachels, *The Elements of Moral Philosophy*, 4th ed. Mc Graw Hill (2003).
11. Louis Pojman, *Ethics: Discovering Right & Wrong*, 5th ed. Thomson (2006).
12. Mike W. Martin and Roland Schinzinger, *Ethics in Engineering*, 4th ed., McGraw-Hill (2004).
13. E. G. Seebauer and R. L. Barry, *Fundamentals of Ethics for Scientists and Engineers*, Oxford (2001).
14. G. D. Baura, *Engineering Ethics: An Industrial Perspective*, Academic Press (2006).
15. R. L. B. Pinkus, L. J. Shuman, N. P. Hummon, and H. Wolfe, *Engineering Ethics: Balancing Cost, Schedule, and Risk. Lessons Learned from the Space Shuttle*, Cambridge (1997).
16. A. Gibney (director), *Enron: The Smartest Guys in the Room* (2005).
17. S. Milgram, *Obedience to Authority: An Experimental View*, Tavistock Publications (1974).
18. Developed by James Rest; See the Center for the Study of Ethical Development, University of Minnesota; http://www.centerforthestudyofethicaldevelopment.net/index.html
19. D. J. Self, and E. M. Ellison, "Teaching Engineering Ethics: Assessment of its Influence on Moral Reasoning Skills," J. Eng. Education, **87** [1] 29-34 (1998).

Biosketches: **Professor Rodney W. Trice**

(a) Educational Preparation

The University of Texas at Arlington, Mechanical Engineering, B.S., Dec. 1987
The University of Texas at Arlington, Materials Science, M.S., Aug. 1989
(Prof. Trice worked in industry for almost six years prior to attending the U. of Michigan in 1995)
The University of Michigan, Materials Science and Engineering, Ph.D., Dec. 1997
Northwestern University, Materials Science and Engineering, March 98 – July 2000 (Post-Doctoral)

(b) Appointments

Purdue University	**West Lafayette, Indiana**
Associate Professor	August 06 – Present
Assistant Professor	August 00 – July 06
Northwestern University	**Evanston, Illinois**
Post–Doctoral Research Associate	March 98 – July 2000
The University of Michigan	**Ann Arbor, Michigan**
Graduate Research Assistant	Aug. 95 – Feb. 98
Northrop Grumman	**Dallas, Texas**
Senior Materials Engineer – Flight Technologies	Feb. 1991 – Aug. 1995
Lockheed Martin – Fort Worth Division	**Fort Worth, Texas**
Engineer – Signature Materials Group	Aug. 1989 – Jan. 1991

(c) Sample of Publications

Trice, RW and Halloran, JW, "The Effect of Sintering Aids on Silicon Nitride/Boron Nitride Fibrous Monolithic Ceramics," J. Am. Ceram. Soc., **82** [11] 2943–7 (1999).

Trice, RW and Halloran, JW, "An Investigation of the Physical and Mechanical Properties of Hot–Pressed Boron Nitride/Oxide Ceramic Composites," J. Am. Ceram. Soc., **82** [9] 2563-5 (1999).

Trice, RW and Halloran, JW, "Influence of Microstructure and Temperature on the Interfacial Fracture Energy of Silicon Nitride/Boron Nitride Fibrous Monolithic Ceramics," J. Am. Ceram. Soc., **82** [9] 2502–8 (1999).

Kovar, D, King, BH, Trice, RW, and Halloran, JW, "Feature Article – Fibrous Monolithic Ceramics," J. Am. Ceram. Soc., **80** [10] 2471–87 (1997).

R.W. Trice, "Web-Based Modules to Increase Relevance in an Introductory Materials Engineering Course," in proceedings from 2005 Illinois/Indiana ASEE Proceedings, May 2005.

Trice, RW and Halloran, JW, "The Elevated Temperature Mechanical Properties of Silicon Nitride/Boron Nitride Fibrous Monolithic Ceramics," J. Am. Ceram. Soc., **83** [2] 311–6 (2000).

Dickinson, G., Petorak, C., Bowman, K. and Trice, R.W., "Stress-Relaxation Testing of Stand-Alone Plasma-Sprayed Tubes of 7 wt.% Y_2O_3-ZrO_2," J. Am. Ceram. Soc., **88** [8] 2202-2208 (2005).

K. Erk, Deschaseaux, C., and Trice, RW, "Grain-Boundary Grooving of Plasma-Sprayed Yttria-Stabilized Zirconia Thermal Barrier Coatings Using Stand Alone Coating Tests," J. Am. Ceram. Soc., 89 [5] 1673-8 (2006).

(d) Synergistic Activities

Basic Science Division Program Co-Chair, American Ceramic Society, 2006-2007 (with Susanne Stemmer of the University of California, Santa Barbara).

Lead organizer of Coatings Symposia for MS&T 2007 Meeting in Detroit, Michigan, October 2007.

Working in cooperation with local science teacher (former teacher of the year for the state of Indiana) to developed a program that invites high school students to participate in my research group for a full year; two females have completed the program to date.

Reviewer for *The Journal of the American Ceramic Society, Materials Science and Engineering A, Surface and Coatings Technology, Phil. Mag., DMR – NSF, DMI – NSF, and others.*

(e) Collaborators & Other Affiliations

(i) Collaborators

Hsin Wang, Wally Porter, S. Speakman, and Jane Howe of Oak Ridge National Laboratory, Dan Sordelet of Iowa State University, Jan Ilavsky of Argonne National Lab, Robert Vassen of Forschungszentrum Juelich.

(ii) Graduate and Postdoctoral Advisors

John Halloran, University of Michigan, Graduate Advisor

K.T. Faber, Northwestern University, Post Doctoral Advisor

(iii) Thesis Advisor and Postgraduate-Scholar Sponsor

Completed: MS: Christophe Deschaseaux, 2002; Emily Pickens, 2003; Narayan Sundaram, 2003; Zun Chen, 2003; Graeme Dickinson, 2004; Batur Ercan, 2005. Christopher Petorak, 2005. Ph.D.: Zun Chen, 2006.

Current: MS: Jeffrey Yankee; Ph.D.: Chris Petorak, and Kent Van Every

(f) Honors

Recipient of a CAREER Grant: *High Temperature Deformation of Stand-Alone Plasma-Sprayed 7 wt.% Y_2O_3-ZrO_2 Coatings*, DMR-0134286, March 2002-February 2007

Reinhardt Schuhmann, Jr. Best Teacher Award, within School of Materials Engineering at Purdue University, 2005

Reinhardt Schuhmann, Jr. Best Teacher Award, within School of Materials Engineering at Purdue University, 2003

National Research Council Postdoctoral Research Associate Award, May 2000, through National Institute of Standards and Technology (declined to accept faculty position).

Regents Fellowship for Academic Excellence for 1995–96, The University of Michigan.

Teaching Assistant of the Year, 1996, Materials Science and Engineering Department, The University of Michigan.

Biographical Sketch: Matthew Krane

(a) Educational Preparation
Cornell University, Mechanical & Aerospace Engineering, B.S., June 1986
Univ. of Pennsylvania, Mechanical Engineering & Applied Mechanics, May 1989
Purdue University, Mechanical Engineering, Ph.D., 1996

(b) Professional Appointments

University of Birmingham, Department of Mechanical and Manufacturing Engineering, Birmingham, UK

Visiting Research Fellow	March – August 2006

Purdue University, School of Materials Engineering West Lafayette, Indiana

Associate Professor	August 03 – Present
Assistant Professor	August 97 – August 03
Visiting Assistant Professor	January 97 – August 97

Purdue University, School of Mechanical Engineering West Lafayette, Indiana

Graduate Research Assistant	May 92 – December 96
Graduate Teaching Assistant	August 91 – May 92

Digital Equipment Corporation, Physical Technologies Group Andover, Massachusetts

Hardware Engineer	August 88 – July 91

PAI Corporation Oak Ridge, Tennessee

Summer Engineering Intern	June – August 87

Univ. of Pennsylvania, Writing Across the University Program Philadelphia, Pennsylvania

Writing Fellow	September 86- May 88

Univ. of Pennsylvania, Mechanical Engineering Department Philadelphia, Pennsylvania

Teaching Assistant	September 86- May 87

(c) Most Relevant Publications for Proposed Research

A. Powell, M. J. M. Krane, and L. Bartolo, "The Transport Phenomena Archive on the Materials Digital Library Pathway," accepted for symposium on "Internet and Other Electronic Resources for Materials Education," 2007 TMS Annual Meeting, Orlando, FL (2/07).

K. P. Trumble, R. Trice, J. Youngblood, E. Kvam, E. B. Slamovich and M. J.M. Krane "Implementation of a unified materials processing laboratory course," ASEE conference, Indianapolis, IN (10/05).

K. P. Trumble, E. B. Slamovich, and M. J. M. Krane, "Implementation of a Unified Materials Processing Laboratory Course," in symposium on "Materials Science and Engineering Education in the New Millennium," MRS Spring Meeting, San Francisco, CA (4/00).

(d) Relevant Synergistic Activities

Invited Speaker, Workshop on "Engineering Ethics," Regional Conference of the National Society of Black Engineers, Purdue University, 12 February 2000.

Invited Speaker, "Professional Ethics from an Engineer's Perspective," Purdue-American Nurses Association Human Rights and Ethics Symposium, Purdue University, 19 September 2003.

Guest Lecturer, "Professional Ethics from an Engineer's Perspective," Nursing 404, *Leadership and Management*, 28 January 2004.

Invited Speaker, "Professional Ethics," Undergraduate Seminar Series, Weldon School of Biomedical Engineering, Purdue University, 12 & 19 April 2005.

Lecturer, "Ethics in Engineering Practice," a ten-part seminar series for REU students in the Weldon School of Biomedical Engineering, Purdue University, June-August 2005.

Faculty Advisor, Kappa Delta Rho Fraternity, Theta Chapter, Purdue University

(e) Honors

Office of Naval Research Young Investigator Award, 2002

Teaching for Tomorrow Award, Purdue University, 2001

(f) Other Publications

S. A. Cefalu and M. J. M. Krane, "Comparison of predictions of microsegregation in the Ni-Cr-Mo system to experimental measurements,", *Mat. Sci. & Engr. (A)*, **454-455**, pp. 371-378 (2007).

J. Hahn, Y. C. Shin, and M. Krane, "Laser transformation hardening of Ti6Al4V in the solid state with an accompanying kinetic model," *Surface Engineering*, **23**, pp. 78-82 (2007).

R. S. Lakhkar, Y. C. Shin, and M. J. M. Krane, "Predictive modeling of multi-track laser hardening of AISI 4140 steel," in press (*Available online 25 July 2007*), *Mat. Sci. & Engr. (A)* (2007)..

I. Vušanović and M. J. M. Krane, "Macrosegregation in horizontal direct chill casting of aluminum slabs," in press, *Mat. Sci. & Tech.* (2008).

M. J. M. Krane, D. R. Johnson, and S. Raghavan, "The development of a cellular automata-finite volume model for dendritic growth," in review, *Applied Mathematical Modelling* (2007).

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Rodney W. Trice

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Plasma and HVOF Spray of Colloidal Solutions to Create Nano-Scale Features in Coatings

Source of Support: National Science Foundation

Total Award Amount: $300,000 Total Award Period Covered: 06/01/05-05/31/09

Location of Project: Purdue University, West Lafayette, IN

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Hot Corrosion Testing of Developmental CVD Coatings

Source of Support: Rolls-Royce Corporation

Total Award Amount $8,600 Total Award Period Covered: 06/15/2008-12/31/2009

Location of Project: Purdue University, West Lafayette, IN.

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 0.2

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Design and Manufacture of Ultra-High Temperature Ceramics with Oriented Strengthening and Toughening Phases

Source of Support: National Science Foundation

Total Award Amount: $250,000 Total Award Period Covered: 9/1/07-08/31/2010

Location of Project: Purdue University, West Lafayette,IN.

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 0.5

Support: ☐ Current X☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Kinetics Studies of Infiltration and Degradation of Thermal Barrier Coatings via Hot Corrosion

Source of Support: National Science Foundation

Total Award Amount: $631,500 Total Award Period Covered: 05/01/09-04/30/2013

Location of Project: Purdue University, West Lafayette, IN.

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 0.5

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

NSF Form 1239 (10/98) USE ADDITIONAL SHEETS AS NECESSARY

Current and Pending Support Cont.

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Rodney W. Trice

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☐ Current X Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Preparation of Ulta-Low Thermal Conductivity Coatings Via Suspension Plasma Spray Using a Defect Clustering Approach

Source of Support: National Science Foundation

Total Award Amount: $316,990 Total Award Period Covered: 06/01/2009-05/31/2012

Location of Project: Purdue University, West Lafayette, IN

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☐ Current X Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Design of Increased Performance ZrB2-Based UHTCS via the use of High Throughput/Combinatorial Methods

Source of Support: Air Force Office of Scientific Research

Total Award Amount: $595,911 Total Award Period Covered: 07/01/09-06/30/2012

Location of Project: Purdue University, West Lafayette, IN

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.D.8 for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Matthew J.M. Krane

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

NSDL Materials Digital Library Pathway: Hub for Materials Education and Research

Source of Support: Kent State University

Total Award Amount: $172,144 Total Award Period Covered: 09/01/05-08/31/08

Location of Project: Purdue University, West Lafayette, IN

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☒ Current Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Control of Transport Phenomena to Enable the Production of TiAl Single Crystals

Source of Support: National Science Foundation

Total Award Amount: $300,000 Total Award Period Covered: 08/15/07-07/31/2010

Location of Project: Purdue University, West Lafayette, IN

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.00

NSF Form 1239 (10/98) USE ADDITIONAL SHEETS AS NECESSARY

Support: ☐ Current X Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

IMI: International Institute for Sustainable Processing and Performance of Materials

Source of Support: National Science Foundation

Total Award Amount: $6,000,000 Total Award Period Covered: 02/01/09-01/31/2014

Location of Project: Purdue University, West Lafayette, IN

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr: 1.0

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.