# ACADEMIC PORTFOLIO

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OVERVIEW

The purpose of this academic portfolio is three-fold. First and foremost it documents – in an empirical, evidence-based fashion – my activities and accomplishments in research, teaching, and service and provides some context for those activities and their significance in nuclear science and technology and in a global sense. Second it is a vehicle for organizing my research, teaching, and service priorities, and for developing and refining my short- and long-term career goals. As such it provides a method for me to evaluate my own strengths and weaknesses and target my professional activities to take advantage of those strengths and address weaknesses. Finally it is a way to describe my key activities to professionals in other fields in a clear, concise fashion for grant applications, proposed collaborations, dissemination of research results, and promotion of the Nuclear Engineering Program, Department of Mining and Nuclear Engineering, and Missouri University of Science and Technology.

A graduate of Purdue University, I received my PhD in Nuclear Engineering in 2012. My advisor was Distinguished Professor Mamoru Ishii, a world-renowned expert in nuclear reactor thermal hydraulics and multiphase flows. On receiving my doctorate I was hired by Professor Ishii as a postdoctoral researcher. My work there included managing all aspects of the laboratory, mentoring graduate students, and key research in multiphase flow. That research included the development of a new type of electrical conductivity probe, various experimental measurements of interfacial area transport phenomena, and the development of a computer code using the one-dimensional two-fluid model to predict multiphase flow development. In 2014 I joined the faculty of Mining and Nuclear Engineering at Missouri S&T as a member of the Nuclear Engineering Program as an Assistant Professor. I very quickly developed a long-term plan for teaching, set key goals for my research program, and involved myself in forward-looking service activities.

The details of those activities will be discussed throughout the rest of this portfolio, along with descriptions of the rationale and significance of those activities. The portfolio will begin with a description of my research program, which has brought in $192,000 of research grants and $160,000 in fellowships funded by the U.S. Nuclear Regulatory Commission to Missouri S&T, and resulted in a total of 22 peer-reviewed journal publications and 202 citations for an h-index of 8 and an i10 index of 7. In addition two more publications are under review. This will be followed by a description of my teaching philosophy, which focuses on team-based, problem-based learning. It will also include a description of my continuing professional development activities and how those activities have shaped my teaching philosophy. Finally I will discuss my service activities, which have been focused on influencing the future development of the Nuclear Engineering Program and Department of Mining and Nuclear Engineering, as well as expanding the visibility of my research program and related activities.
I was a junior in Nuclear Engineering at Purdue University, and was struggling during the Fall semester of that year. I was working two jobs to pay tuition and taking a full time course load. Staying up until 2 a.m. working meant that I was missing some class time, particularly in the course “Fundamentals of Nuclear Engineering”. My partner in the course dropped out of sight after the first exam, so I was finishing group homework on my own each week. I was still making an A in the course, but it would be generous to call it a challenge. The professor teaching the course took notice, and took me aside after class one day to ask me what was going on. I explained about working and my partner not being around and promised her that I would ask for help if I needed any, then went on my way. I really didn’t think anything of it. A few days later she took me aside again and said “I think you need to be involved in research. Pick any professor in the department that you would like to work with and I will talk to them to recommend you.” I spent a few days looking through the research each faculty was doing and what courses they were teaching. In the end I asked for a recommendation to Distinguished Professor Mamoru Ishii, a world-renowned expert in nuclear reactor safety. The next day she told me I should show up at his office at 9:00 on Thursday morning.

I will admit to being just short of terrified about meeting him. I hadn’t had any courses with him, and I had heard from some of the graduate students that – let’s just say he had very high standards, and not all of the students met those standards. However the angst was really unnecessary. We spoke briefly about some of the research he was doing, he had a few questions about my transcript and work background, and we discussed my research and career interests. After about half an hour he agreed to hire me as an undergraduate laboratory assistant to work on a new project. I found out later that I am the only undergraduate student he ever hired. This really turned my year around. I still had to work two jobs, but now one of them was interesting and directly related to my chosen field. I had additional academic support, due to spending more time with faculty and because I had the chance to work with graduate students in the field. As a faculty member myself, I hope that I can have that kind of impact on the students I work with every day.

So I decided that I wanted to follow in their footsteps. I continued on to graduate school with Prof. Ishii as my advisor. In addition to research I was active in service and sought out chances to teach. I was one of the founding members of the Nuclear Engineering Ambassadors, a group of top students given responsibility for assisting in recruitment and fundraising events. I was the graduate student representative for our local chapter of ANS. I travelled to local high schools to give presentations. When faculty were traveling to conferences, I asked if I could teach their class while they were gone. This was – and still is – sometimes difficult for me because I am not naturally outgoing and talkative. But it was important to me, and well worth the effort. In research, I asked to help write proposals and be given more responsibility. After watching me talking with prospective freshmen on morning, the student services assistant responsible for advising all the students in the department told me “If you don’t become a professor and teach, you will be
wasting your talent.” My advisor appreciated the fact that if he asked me to do something, he knew that if he left me alone it would get done on time without the need for close supervision or micromanaging. After I earned my doctorate he hired me as a postdoc. In that position I was responsible for managing all of the active research projects and acting as an interface between my advisor and the graduate students working in his laboratory. This was my first exposure to the administrative side of academic research, and I learned a lot in the first few months. But after about a year and a half we met to discuss my future plans. He said that “I think you have learned everything you can from working here, you are ready to move on”. A few months after that, I was hired here at Missouri S&T.

I have had to overcome challenges while here as well. Due to renovations to Fulton Hall the research space I was promised when I arrived was lost a few months later. I was eventually able to find new research space, thanks to Dr. Joseph Smith and the ERDC, and submitted a request for Physical Facilities to install key equipment. At this point, almost three years after my arrival, the equipment installation is almost complete. I have been moderately successful obtaining research grants for analytical and computational research, but experimental research is my true passion and I am looking forward to finally having the facilities available to begin that effort in earnest. I have also been trying to balance research efforts with higher-than-usual teaching loads for an early-career faculty member. I have been teaching two or three courses each semester, and have had to prepare nine different courses during my first seven semesters as a professor. However constructive criticisms from the students have been very helpful in adjusting my teaching methods to the needs of the learners.

On a personal note the birth of my two sons – Ethan just before I arrived at Missouri S&T and Larkin two years later – has been both a blessing and an adventure for my wife Amanda and I. Ethan spent two months in the hospital before he was able to come home – two weeks of that attached to a heart-lung machine that breathed for him – due to a serious case of pneumonia. But he fought very hard to heal and he has grown into a precocious and energetic almost-three-year-old. Larkin is toddling around the house and yard, and is just beginning to talk and throw temper tantrums. It is a joy to arrive home at the end of each work day to spend the evening playing with cardboard boxes, blocks, Legos, cars, and whatever else seems interesting to them that day.

Overall I believe that I have been quite successful. The remainder of this document will cover, in excruciating detail, the numbers proving that case: research dollars, CET scores, and everything else. But more important to me are the students who have told me “I am lucky that you were my advisor,” “You are going to be a great teacher,” or “I learned so much from that class, it has really helped in my other classes.” I have already begun to have an impact on the students I interact with every day, as the professor in that Fundamentals of Nuclear Engineering course had on me.


RESEARCH AND SCHOLARSHIP

INTRODUCTION

All university-level research programs have certain common goals: discovering new knowledge, integrating that knowledge with what we already know to achieve a deeper understanding of the world around us, applying knowledge to make the world a better place, and teaching that knowledge to others so that they can continue the process. Within that framework each individual faculty member has specific long- and short-term goals related to the development of their field. My research has been focused on the application of the principles of heat, mass, and momentum transfer to nuclear reactor systems.

In the long-term, my goal is to become a nationally and internationally recognized expert in multiphase flow processes, specifically in the improvement of nuclear reactor performance and safety and energy efficiency. I plan to accomplish this goal by:

- Improving our scientific understanding of key phenomena important to industrial applications such as turbulence, interfacial behavior, and so on.
- Applying fundamental principles of physics to develop, evaluate, and refine models for multiphase flow systems
- Validating those models using high-quality experimental measurements and innovative measurement techniques
- Mentoring PhD candidates to produce qualified, creative faculty to continue developing the field.

My general research interests have been focused in a few key areas. One has been creating new methods for evaluating and optimizing multiphase flow models. From this area has grown a vested interest in the development of new instrumentation – and the continuing improvement of existing types of instrumentation – for measuring important parameters in two-phase flows. Finally, I have also been involved in applied research – solving key problems related to industrial applications of multiphase flows. These areas are detailed below.

Throughout this process, my efforts have led to numerous publications and citations and significant research funding. Figure 1 shows the number of peer-reviewed journal publications that have been produced each year. This number does not include a book chapter on two-phase flow in large diameter pipes, nor does it include peer-reviewed conference proceedings. The figure shows an average of 2-3 publications per year over the last five years, however it also shows that I have six publications published this year with two more currently in press or under review, and 6 papers currently being written. Perhaps more important than publishing is making sure that people are reading and using the work. Figure 1 also shows the rate of citations since 2009. As the figure shows, the number of citations has been steadily increasing each year. Based on data obtained from my Google Scholar profile, I have a total of 202 citations (198 since 2011), an h-index of 8, and an i10-index of 7. Funded research grants are listed in Table 1. As the table indicates, I have brought $192,500 in research funds to Missouri S&T over the last two years. In

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addition I have been co-PI on two proposals to provide undergraduate scholarships to Missouri S&T students. Both proposals were funded by the U.S. Nuclear Regulatory Commission, and my share of that funding is an additional $160,000. Additional details can be found in my Curriculum Vitae, in Appendix A.

Also important is the development of a national and international reputation for excellence. I have already begun to develop such a reputation. I have developed a collaboration with Dr. Xuizhong Shen, a researcher at the Kyoto University Research Reactor Institute in Japan. I have been approached by the Institute of Nuclear Safety Systems, a subsidiary of the Kansai Electric Power Company in Japan, to perform funded research on reactor safety analysis codes and model

Table 1: Funded Research Activities

<table>
<thead>
<tr>
<th>Project Title</th>
<th>Sponsor</th>
<th>PI</th>
<th>Performance Period</th>
<th>Total Funding</th>
<th>Investigator Portion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improved Drift-Flux Model for Rod Bundles at Elevated Pressures</td>
<td>Insitute of Nuclear Safety Systems, Inc. (Japan)</td>
<td>Dr. Joshua P. Schlegel</td>
<td>August 15, 2015 - March 31, 2016</td>
<td>$30,000</td>
<td>$30,000</td>
</tr>
<tr>
<td>Experimental Validation of Models and Simulations in Nuclear Systems</td>
<td>University of Missouri Research Board</td>
<td>Dr. Joshua P. Schlegel</td>
<td>February 1, 2015 - January 31, 2017</td>
<td>$55,000</td>
<td>$55,000</td>
</tr>
<tr>
<td>Condensation Heat Transfer Experiment and Scaling</td>
<td>Small Modular Reactor Research and Education Consortium</td>
<td>Dr. Shoaib Usman</td>
<td>July 1, 2015 - June 30, 2016</td>
<td>$90,000</td>
<td>$36,000</td>
</tr>
<tr>
<td>Code Development for Bubble Coalescence and Breakup - II</td>
<td>Chevron Energy Technology (Purdue University)</td>
<td>Dr. Takashi Hibiki</td>
<td>March 1, 2015 - December 31, 2015</td>
<td>$120,000</td>
<td>$46,500</td>
</tr>
<tr>
<td>Interfacial Area Transport Study in Gas-Dispersed Flow</td>
<td>Bettis Atomic Power Laboratory (Purdue University)</td>
<td>Dr. Mamoru Ishii</td>
<td>August 1, 2012 - December 31, 2016</td>
<td>$615,000</td>
<td>$153,750</td>
</tr>
<tr>
<td>Code Development for Bubble Coalescence and Breakup</td>
<td>Chevron Energy Technology (Purdue University)</td>
<td>Dr. Takashi Hibiki</td>
<td>March 1, 2014 - December 31, 2014</td>
<td>$100,000</td>
<td>$50,000</td>
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* This funding was obtained while a postdoctoral researcher at Purdue University. A total of $25,000 in funding was transferred to Missouri S&T as a subcontract.
development. As a graduate student I travelled to Japan to train engineers at Mitsubishi Heavy Industries in the use of key instrumentation that I developed for them. I have fielded requests for information and assistance from researchers in various fields and nations. Some examples of email correspondence regarding these requests are included in Appendix B. Finally, my work has been cited by researchers in a wide range of fields and by researchers across the globe. Some selected examples of the works that have cited my publications are included in Appendix C. The fields range from nuclear applications, to the propagation of gas bubbles in volcanic magma, to the development of models for gas-oil flows in oil wells.

Last, but not least, is the mentoring of PhD candidates. As a junior faculty member I am still developing those students. However I expect to have one of my advisees complete their Ph.D. program within two years, with two additional students completing their PhD programs within three years.

**DESCRIPTION OF RESEARCH**

*Database Development for Code Validation*

The first step in the scientific method is observation – the collection of experimental data, and a key part of creating new knowledge. Experimental data is also intimately involved in testing hypotheses (models) that are developed to explain those observations. To that end, I have performed a great deal of experimental work over the course of my career.

A significant portion of that experimental work has been the collection of an extensive database of bubble behavior – void fraction distributions, interfacial area concentration distributions, fluctuations in the void fraction with time, and other data important to the validation of models in nuclear reactor systems. These experiments have relevance in a wide range of systems. These include:

- Large diameter tubes such as oil wells and vertical risers, chemical processing systems, and vertical risers in natural circulation Boiling Water Reactors.
- Tube bundles such as nuclear reactor cores and steam generators and chemical process cooling systems
- Rectangular channels such as those found in many nuclear research reactors and nuclear reactors for Naval applications

The resulting data has been used by organizations ranging from the **U.S. Nuclear Regulatory Commission, Bettis Atomic Power Laboratory, and Chevron Energy Technology** in order to validate computer codes. At the NRC this includes **validating TRACE**, an industry-standard nuclear reactor safety analysis code, and the development of TRACE-T, a beta-version code which includes implementation of detailed bubble coalescence and breakup models. Bettis Atomic Power Laboratory has used the experimental data to **validate the multiphase flow models in commercial CFD code CFX**, produced by ANSYS. Chevron Energy Technology is using data I produced to develop **design improvements in their oil processing systems**, saving money and improving resource utilization.
Figure 2: Detailed local profiles of phase concentration and interfacial area concentration collected in large diameter tubes

I am currently in the process of establishing the Thermal Hydraulics Experiment and Modeling for Energy applications (THEME) laboratory at Missouri S&T. Infrastructure necessary for experimental research is currently under construction by Physical Facilities at Missouri S&T with an expected completion date in August of 2016. When that work is completed I expect to establish a series of test facilities that will allow me to continue my efforts in the area, including a flexible interfacial area transport test facility that will allow the installation of multiple channel geometries, upwards or downwards vertical flow, and testing of advanced instrumentation. I also plan to begin work on a facility that uses Sulfur Hexafluoride gas rather than air to perform multiphase flow...
experiments. This gas is much denser than air at atmospheric pressure allowing the evaluation of high-pressure scaling effects without the risks associated with high-pressure testing.

Optimizing and Evaluating Two-Phase Flow Models

The second through fourth steps of the scientific method are developing hypotheses, testing hypotheses, and revising hypotheses. The optimization and evaluation of two-phase flow models falls under these steps. As part of this work I have developed new flow regime maps and drift-flux models in large diameter tubes. The publication that resulted from this work, published in 2010, became one of the 10 most-cited papers in the journal Progress in Nuclear Energy from 2010 to 2014. Progress in Nuclear Energy is a Q1 journal in nuclear
science and engineering with an h-index of 34 (http://www.scimagojr.com/journalrank.php?category=1710). I have also spent time evaluating the prediction uncertainty of the two-phase flow models used in RELAP, another industry-standard safety analysis code.

The centerpiece of this portion of my research has been the development of a modular, one-dimensional two-phase flow analysis code using MATLAB. Based on the two-fluid model used in RELAP and TRACE, I took the work a step further and implemented a full two-bubble-group approach with void transport and interfacial area transport. At this time the code is limited to vertical flows without heat transfer, and it is a powerful tool for evaluating models. All of the constitutive models within the code are modular, allowing me to evaluate the sensitivity of the system to changes in the various parameters that are key to accurately predicting multiphase flows.

In the spirit of that effort, I have developed an objective optimization technique for two-phase flow models that uses this code as a key component. Using principles from Pareto optimization and implementing a modified form of the Gauss-Newton algorithm, I was able to make some key revisions to the two-group bubble coalescence and breakup models for large diameter tubes. The resulting model was able to reduce the interfacial area concentration prediction error from 52% to 33%.

![Figure 5: Graphical User Interface for Two-Fluid Model Code](image)

I am continuing to use this approach to evaluate the sensitivity of the code to key models. At this time I am focusing on the drift-flux type correlations which are used to calculate the interfacial...
drag forces, thereby determining the phase concentrations, flow rates, and coolant inventory in nuclear reactor systems. In the near future I will also be evaluating various interfacial area concentration correlation schemes and the addition of void covariance effects in the two-fluid model, a phenomenon which has been neglected until now.

Advanced Instrumentation for Two-Phase Flows

In the spirit of enhancing the ability of researchers to provide high-quality data for validation of models, I have also been part of the development of advanced two-phase flow instrumentation. As a graduate student I developed a computer-controlled electronic positioning system capable of positioning void probes inside of a flow channel to within 0.1 mm. Previously, void probes had been positioned by hand using micrometer scales. I then combined this with a multiple-void-probe system and a high-capacity data acquisition system capable of collecting up to 2.5 million samples per second. As a result I was able to perform complex experiments in 15-20 minutes that previously required 3-4 hours.

I am currently working with researchers at Purdue University and Bettis Atomic Power Laboratory to develop a void probe capable of measuring droplets and differentiating them from the continuous liquid in a multiphase flow system. This work is related to the dryout phenomenon, which occurs when the liquid film covering a heated surface completely evaporates. In nuclear systems, this can lead to overheated fuel, cladding damage, and fuel damage. Avoiding this condition requires
reliable computer models, which must be validated against high-quality, experimental measurements. To provide these measurements I have been working with collaborators to develop a multiple-sensor electrical resistivity probe that is able to measure the droplet fraction, thereby providing data on the fraction of the liquid phase that is available on the heated surface. The probe will be used to collect extensive data under annular flow conditions to assist in code validation.

Enhancing Passive Safety in Nuclear Reactor Systems

My interest in enhancing passive safety in nuclear reactor systems is driven by the rise of small modular reactor (SMR) systems. These reactors are much smaller, and therefore have much smaller thermal loads. This lends them to various passive safety systems that are impractical in larger designs. One of the most direct applications is the use of Phase Change Materials (PCMs) in SMRs. PCMs are materials that are designed to freeze and melt at a specific temperature, and have a high heat of fusion. This allows them to absorb large amounts of thermal energy at a relatively constant temperature.

In the long term, I plan to develop research on the application of high-temperature PCMs to enhance passive safety in nuclear reactor systems. Some work has already been done in this area by researchers at MIT, who proposed using a large block of PCM to moderate thermal output from a high-temperature gas-cooled nuclear reactor. This system was designed to moderate the electricity output from the reactor and enhance the load-following capability of nuclear reactor systems, and had the desirable side effect of absorbing thermal energy, thereby reducing the temperature of the fuel during accident scenarios. I hope to design PCM systems that change phase in the temperature range of 100°C to 300°C and can be incorporated into the emergency core cooling systems of modern reactor systems. My specific interest is in the suppression pool and reactor containment. Incorporating PCMs with phase change temperatures in the range of 90 – 100°C in the suppression pool and containment structure has the potential to absorb more heat, reduce the containment pressure, and extend the time during which key safety systems are able to operate.

I have begun this work by investigating room-temperature PCMs. While this is a first step in a larger research program, it also has important potential impacts. Heating and cooling comprises as much as 24% of the energy consumed in the United States each year. The use of PCMs can reduce energy consumption in this area by 30% to 50% [1], reducing energy costs and greenhouse gas emissions.

This potential is widely recognized, as evidenced by recent experiments at Oak Ridge National Laboratory [1]. Recently, my research team developed a novel eutectic PCM using Methyl Palmitate and Lauric Acid, both naturally occurring fatty acids. The table below lists the key properties of these PCMs:

<table>
<thead>
<tr>
<th>PCM</th>
<th>(c_{p,s} ) [J g(^{-1}) K(^{-1})]</th>
<th>(c_{p,l} ) [J g(^{-1}) K(^{-1})]</th>
<th>(T_m ) [°C]</th>
<th>(\Delta h_m ) [J g(^{-1})]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methyl Palmitate</td>
<td>1.704</td>
<td>2.015</td>
<td>29.06</td>
<td>202.2</td>
</tr>
<tr>
<td>Lauric Acid</td>
<td>2.056</td>
<td>2.045</td>
<td>43.98</td>
<td>180.8</td>
</tr>
<tr>
<td>60MP/40LA</td>
<td>1.513</td>
<td>1.952</td>
<td>25.5</td>
<td>205.2</td>
</tr>
</tbody>
</table>

Table 2: Key Properties of PCMs
acids. The resulting PCM has a melting temperature of 25.5ºC and a heat of fusion of 205.2 kJ/kg. This temperature range is ideal for heating and cooling applications, and the heat of fusion is as much as 20% higher than other PCMs developed for this application. However the thermal conductivity of PCMs is typically low, resulting in large thermal gradients that impede the ability of the materials to maintain the internal environment at a constant temperature. To remedy this, we included graphene nanoplatelets into the PCM. This did not alter the melting temperature, but resulted in an increase of as much as 100% in the thermal conductivity of the PCM. It also reduced the total energy storage capacity of the mixture to about 180 kJ/kg, however this is comparable to other PCMs in the scientific literature. Over the next two years I plan to investigate alternative eutectic PCMs, which have the potential for heats of fusion as high as 250 kJ/kg. I also plan to investigate various types of nanoparticles for thermal conductivity enhancement, including using carbon nanotubes – with directional thermal conductivity. I would like to try using magnetic nanoparticles embedded on the nanotubes to align them to provide maximum thermal conductivity in the direction of interest. This work will fund further investment and allow an expansion of my work in this area. In the next 5-10 years I would like to begin looking at slightly higher temperature PCMs with applications to solar energy collection, conventional electricity generation, battery performance, and medical applications. This continuous investment will enable the acquisition of key equipment needed in order to move on to high-temperature nuclear applications.

**Applied Research on Two-Phase Flow Phenomena**

In addition to fundamental scientific and engineering work, I have been involved in a number of important applied research projects for a variety of sponsors. During work for Mitsubishi Heavy Industries on the design of a chemical scrubber for flue gas from coal power plants I created a dynamic solver for droplet behavior. The solver was able to calculate the droplet fraction and determine the conditions for which instability due to counter-current flow limitation would occur, allowing MHI to avoid these conditions and optimize their final design. This led to additional work from that sponsor, including the development of an impedance void meter capable of quickly evaluating the symmetry of the void fraction profile in a pipe. That work included the design and construction of a scale model system, experimental validation of the measurement principle, and construction of a full-size prototype 30 cm in diameter. At the culmination of the project I travelled to their testing facility in Japan to assist in the installation and calibration of the instrument and train several of their engineers in its use. The technology was used to evaluate the effect of upstream conditions on pump degradation due to void ingress, leading to better
guidelines for designing and operating emergency core cooling systems in nuclear reactor systems.

That project was closely related to work that I did for Westinghouse Nuclear. Generic Letter 2008-1 (US NRC) highlighted air ingress in emergency core cooling systems as an issue that needed to be urgently addressed. Over three years I worked on the design, construction, and testing of four scaled experimental facilities designed to mimic the behavior of emergency cooling pump systems with diameters of 0.1 to 0.3 m. The test facilities included clear visualization ports, high-speed video capture, and detailed void fraction measurements at various points along the suction piping for the pump. The results were used by Westinghouse Nuclear to justify the safety of the systems to the NRC.

More recently I was the PI on a project for the Institute of Nuclear Safety Systems (INSS), a subsidiary of the Kansai Electric Power Company in Japan. This project involved significant literature search, evaluation of existing data regarding the boiling of water in nuclear reactor cores, evaluation of the sources of the data and the associated uncertainties, and the recommendation of a transition model for moderate pressures – from 0.5 to 5 MPa, to bridge well-known conditions at nearly atmospheric pressures and at full-pressure operating conditions of 7 to 15 MPa. This moderate-pressure region is important for the prediction of certain portions of small-break loss of coolant accidents, but very little experimental data is available in that region. INSS implemented the resulting model in their custom version of RELAP5 and is currently evaluating the recommended model against the data available in the scientific literature.

I am also a co-PI on a project for the Small Modular Reactor Research and Education Consortium (SMRrec). This project involves the design and construction of a test facility to investigate scaling effects on condensation heat transfer in SMR passive cooling systems. Experimental data collection, analytical modeling, and computer simulation will be performed to evaluate the ability of current models to predict steam condensation heat transfer rates in the presence of non-condensable gases. The results will be used by the Consortium members in their licensing applications to the US NRC.

Cited Works:
TEACHING AND MENTORING

TEACHING PHILOSOPHY

I would begin this section with a disclaimer: this is less of a teaching philosophy than it is a learning philosophy. After all, we do not evaluate faculty on how much they teach, but on how much their students learn. Those of us from academia have a long history of learning – and should therefore have a great deal of experience to draw upon. One of my best experiences as a learner was in my high school calculus and physics courses. Both courses were taught by the same person. What I remember most about those classes was the sense of discovery – the ‘aha!’ moments that occurred throughout the class. I realize now that those moments were the result of his careful planning – that he guided us toward the answer almost without us realizing that we were being directed. That is what I hope to be able to do for my students, and I think that the students have gotten that message. Many of my student comments include some variation of “The most kind and caring professor I have ever had. He truly wants all of his students to succeed.”

During my time at Missouri S&T I have spent a lot of time trying to learn the best ways to achieve this goal. Participating in activities like the Freshman Faculty Forum, University of Missouri Faculty Scholars, Curators’ Teaching Summits, and many other discussions on campus, as well as reviewing key literature, has been very helpful in this regard. Being exposed to the idea of the VARK learning inventory (Marcy, 2001) was a powerful experience for me, and I began using it to design more varied instructional activities that would appeal to various learning styles. I also have the students fill out the inventory and learn more about their learning styles on the first day of class, which helps them develop study strategies for their other classes as well. More exposure to learning theories such as Bloom’s taxonomy and the Depth of Knowledge chart provided me information that has allowed me to target assignments to the skills and knowledge that I want the students to take out of my classroom. One thing I have struggled with during my first years as an instructor is keeping students engaged with the material, as evidenced by some of the student comments in Appendix E. My introduction to team-based learning strategies (Michaelson et al, 2004) has given me a new tool that I think will significantly improve student engagement in the classroom – I intend to implement team-based class examples, team-based homework assignments, and a team-based project in my courses next year to test the technique. Of course it is also important to remember that the students are the best source to tell us what they are learning. To that end I have implemented formal mid-semester feedback from the students in my classes, allowing them to evaluate my performance and provide suggestions. I have tried to incorporate many of those suggestions as mid-semester course corrections. I also solicit less formal feedback during LEAD sessions and during individual discussions with students. These activities have also provided some valuable advice and suggestions.

To move the students toward that ‘aha!’ moment, it is important to keep in mind the purpose of teaching. Why do we want to pass on what we know? The answer seems obvious, but is often lost
in the noise of developing lesson plans, educational activities, and assessments. To me, the purpose of teaching is to (1) help students understand the concepts and ideas behind the equations and the real-world meaning of the facts that they can read in their textbooks, (2) give them the ability to bring together the pieces of their education and understand how they work together to describe real processes, (3) show them how to use their existing knowledge and critical-thinking abilities to develop new ideas, and (4) instill in students a passion for learning and discovery. These four goals should be the measuring stick for our success or failure as educators. Of course, how to go about achieving those goals is another matter entirely. Note that the subject matter is of little significance to these classroom goals. While the subject matter is important, I believe that it should be used as a vehicle to teach more fundamental skills that the students can use and apply in the many and varied topics and areas that they will be expected to work in. I also believe that people tend to rise or fall to the level that is expected of them. I will admit to having very high expectations of our students, but I have found that once the students understand what those expectations are many of them rise to the challenge. I also believe that treating them like adults, with honesty and high - but realistic - expectations, allows them to treat themselves like adults and take the responsibility for their performance on themselves. One of my students commented “Very tough, made me push hard to earn a grade.”

There are some basic principles that I believe are very important to any attempt at education. The first principle is that teaching is essentially a form of communication. In fact teaching could be considered a form of performance art. Vocal inflection, body language, humor – all of these factors communicate information to your audience above and beyond the words you use. A good educator uses these nuances of communication to convey passion and excitement for the topic along with the course material. I always make an effort to be an active speaker, moving around the room, varying inflection, and so on. I also incorporate a little bit of humor into my lectures – sometimes you also need to be able to accept and understand that your own mistakes can help students connect with you, if you don’t take yourself too seriously, are willing to admit to them, and ask the students to show you where you went wrong. This approach can be seen in the student comments in Appendix E, such as “Invests the time to cover examples in detail. Works clearly and easy to follow. Good communicator.” It is also essential to know your audience and adjust your teaching methods to fit. An excellent example of this is LaMar Queen, a math teacher in Los Angeles, who was recognized for his efforts to reach inner-city students. He converted his math lessons into rap songs to help students remember the content. By using a format that the students enjoyed, he helped them learn more easily, remember more clearly, and apply more readily. As my students have said, “Dr. Schlegel was willing to improve on his teaching skills and in the way he taught constantly, which was one of his biggest strengths.” It is also important to relate your lessons to the other lessons in the course, to applications in industry, and to one’s own research experience. This helps keep students interested by showing them how the material they are learning has real-world applications and uses, and helps them to remember the information by connecting material to a memorable story or event as well as other important subjects. I have been working to improve this in my courses, and the students have noticed: “Keep doing examples.
They were great! “

Second, student participation is essential to learning. It requires the student to absorb and process the information immediately, rather than passively listening and writing notes. Encouraging questions and in-class activities that focus student attention keeps them engaged and helps promote independent thinking. That is why I am moving to team-based learning in the courses I teach – to promote discussion and critical thinking, and to allow for more active instructional techniques to increase engagement. I enjoy working together with the students to find answers using leading questions and suggestions rather than telling them the answer, and the students appreciate the experience. One student said “As much as the students may not like it, you should force participation in class...” The use of information technology in the classroom can also be helpful to disseminate information, and promote peer interactions via discussion boards, thereby encouraging students to find answers from their peers rather than from persons of authority.

Third, students must have the opportunity to apply what they learn. For this reason I am also beginning to apply problem-based teaching techniques in the classroom. I use real-world examples, then have the students work in teams to come up with a recommendation to solve the real-world problem using the material we are discussing in class. I also plan to use open-ended or forward-looking questions in homework assignments and exams to encourage critical thinking rather than rote memorization and to remind the students of the real-world implications of their classroom instruction.

Finally, we need to remember that learning should be fun. Learning is exploring the world around us in new ways. It is our responsibility to show students that even after decades of working in our fields we still enjoy our work and continue to discover new and interesting things.


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**TEACHING RESPONSIBILITIES**

At Missouri S&T my teaching responsibilities varied somewhat during my first few semesters. As a result, I have taught nine different classes over my first seven semesters at Missouri S&T. At this point I am typically responsible for four classes each year: Reactor Fluid Mechanics (NUC ENG 3221), Reactor Heat Transfer (NUC ENG 3223), Introduction to Nuclear Thermal Hydraulics (NUC ENG 4257/5257) and Advanced Nuclear Thermal Hydraulics (NUC ENG 6257). The syllabi for these courses can be found in Appendix D. I am also co-teaching the capstone design courses, NUC ENG 4496 and NUC ENG 4497, with two other faculty. My overall effectiveness scores and scores for ‘would you recommend this professor’ for these courses can be found in Table 3. A summary of these scores, grouped into Junior/Senior Required Courses, Senior Technical Electives, and Graduate Courses, can be found in Figure 10.
Table 3: Student Evaluation Scores

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<th>Spring 2016</th>
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Among positive comments during my first two semesters were (a more complete list of selected comments can be found in Appendix E):

- “Excellent knowledge of material and availability outside of class.”
- “Very hard working and cares about his students. More importantly sticks to the rules which is of great commendation.”
- “Although this is the first time for the instructor to teach this course, the instructor tried his best to teach well.”
- “The professor was well organized and effectively presented course material.”
- “Instructor is very concerned about students understanding and enjoys the topic.”
- “Have the professor be willing and excited to learn how to teach, as he currently is.”

However there were also some constructive criticisms:

- “There was no hand on realization on the subject matter.”
- “Weaknesses: Inexperienced in teaching practices, and different learning styles.”
- “Weakness: The fact that he knows the material so well causes him to skip explanations of intermediate steps.”
- “Less test, more projects!”

One key criticism was that my exams were too long and were more difficult than other exams. This was deliberate on my part, as I was testing out an approach. However the experiment was not successful and I plan to make some changes going forward. This was the most important reason my evaluations in NUC ENG 3221 and NUC ENG 3223 have been poor, as my ratings in the individual categories were much higher than my overall ratings.

After the first year, I continued to focus on areas of strength. Some positive comments I
received after my second year were:

- “The most kind and caring professor I have ever had. He truly wants all of his students to succeed.”
- “Invests the time to cover examples in detail. Works clearly and easy to follow. Good communicator.”
- “The instructor is very passionate about the material and knows it very well.”

However I made a number of changes as well. I made particular efforts to remain flexible in my teaching methods, to allow me to respond quickly to student feedback:

- “Dr. Schlegel was willing to improve on his teaching skills and in the way he taught constantly, which was one of his biggest strengths.”
- “The instructor was willing to re-evaluate his grading policy and correct any errors he made on his behalf.”
- “Since last semester, Dr. Schlegel has improved his teaching methods significantly. He's trying to figure out effective ways to teach, and he is clearly making progress. He constantly asks for feedback from his students throughout the semester, and when it's provided, he implements a correction to his methods promptly.”
- “I liked the group involvement of solving problems. As long as everyone in the group participates, I think this would be very effective.”
- “Posting practice problems on blackboard was great! I used them a lot when studying and working on homework problems.”

I believe that this effort was successful and that the students have learned. Several students commented that the material they learned was very valuable to them:

- “It's a great class to prepare us for real world problems but sometimes overwhelms a person never seeing the content before.”
- “This course is difficult, requiring a lot of focus and studying. However, the educational payoff through understanding is immense.”
- “I felt that the course held a LOT of very important and vital information.”

There have also been a few additional constructive criticisms which I intend to address next time the courses are offered:

- “I think sometimes he relies on notes too much and gets in a routine.”
- “I would suggest more practice problems and more lessons on the conceptual ideas of each topic.”
- “The instructor could spend more time focusing on example problems and less time focusing on things that could be easily learned from the textbook.”
- “A forgiveness matrix i.e. a way to replace a test grade, extra credit, or the ability to re-do some homework or replace a homework grade.”
- “Make the course more related to nuclear material, rather than being so broad.”
- “The content taught in the class is very low level compared to the knowledge required in the homework.”

In addition to addressing these concerns, next year I will be implementing a team-based learning
program in my undergraduate courses. Students will be assigned teams of four at the beginning of the semester. These teams will remain for the entire semester. During class, student teams will compete with one another to solve example problems. In addition teams will work together and submit joint homework assignments. This should allow inclusion of more complex, forward-looking questions that require more in-depth analysis, permitting me to integrate the homework assignments into the course as a learning tool in addition to an assessment. Finally students will be expected to complete a short final project and submit a written report.

UNDERGRADUATE AND GRADUATE MENTORING

The mentoring of graduate and undergraduate students is a key component of our efforts as university faculty. A detailed list of my undergraduate and graduate student supervision can be found in my Curriculum Vitae in Appendix A. To summarize, I have supervised two undergraduate researchers and plan on involving many more in research over the next few years. I have had one student complete a MS, and that student is continuing his work to obtain a PhD. I have one other student currently working toward a MS, and am advising 5 students in their PhD study. I expect my first two PhD graduates within two years. In addition, I have served/am serving on the advisory committees of 10 graduate students. This includes one student who is studying at Purdue University, where I was invited to be an outside member of his committee.

I spend a great deal of time working with students. I have an open-door policy – any time I am in my office the door is open, and students can stop in to discuss issues they are having. I make sure to work with students on not only their scientific and technical skills, but also their professional development and communication skills. I hold group meetings for all of my graduate students every other week to keep everyone updated on current research, progress, and goals. I assess the students each semester, and share the results of the assessment (including recommendations for addressing weaknesses) with the students.

I encourage the graduate students under my supervision to seek out and attend professional development workshops – resume writing, interview skills, and so on - and attend career fairs and annual society meetings and conferences. In addition I make myself available to read and comment on their CV, discuss the interview process and answer any questions they may have.

Finally, I emphasize the need for clear communication. I expect students to present to their peers at least once prior to defending their dissertation through our department graduate seminar, and work closely with them on writing the presentation and on their delivery skills. I also expect students to prepare manuscripts for publication, and take them through the process step by step from determining objectives and preparing an outline to writing the various sections and developing clear conclusions. I also encourage students to attend grant-writing workshops, then involve the students in helping me prepare proposals for funded research.
SERVICE

SERVICE PHILOSOPHY

Many faculty treat service as an obligation to be avoided. As junior faculty we are often told to focus on research and teaching – that service is somehow less important. I disagree with this view. Service should be just as forward-looking and strategic as research and teaching, if not more so. Service is a great way to increase visibility and make an impact on the future of the discipline, university, and department. It is a way to build strong professional relationships and develop partnerships. It is a vehicle for sharing knowledge and creating ideas.

This outlook on service has been developed over a long time, but one of the most influential factors in this process was the time I spent in the Boy Scouts. Service was a strong component of my troop’s activities. In the process of earning the Eagle Scout award planning and carrying out service activities is a major component. When I was going through that process I wanted to make sure that my service activity would have an impact – even if no one really knew about my involvement. That attitude has carried over into my professional career, as evidenced by my many service activities as a graduate student. A list of these service activities can be found in my Curriculum Vitae in Appendix A. This culminated in an Outstanding Service Award from my alma mater, Purdue University.

Since arriving at Missouri S&T I have worked to continue that record. I have requested committee assignments that put me in a position to have a positive impact on the future of my department. Professionally, I have actively sought out reviewing assignments and been an active participant in highly visible professional conferences. These assignments will be detailed in the next few sections.

DEPARTMENTAL AND INSTITUTIONAL SERVICE

As stated above, my departmental and institutional service has been focused on areas that will allow me to have a positive impact on the future. Some of this service includes things as basic as meeting with prospective students or developing courses. In addition I have initiated some activities that do not fall under a committee – such as a review of the number of students, number of faculty, and key productivity measures for high-ranking Nuclear Engineering programs. The hope is that this process will help us identify areas that we can address to improve our impact and visibility. I make sure that I am available to help other committees when necessary and strive to be involved in departmental concerns and development. Much of this work is integrated with my every-day teaching and research activities, however I would like to take this opportunity to address a few key areas:
Freshman Engineering Advising

Along with Dr. Gary Mueller, I advise the students in the Freshman Engineering program who have indicated an interest in Nuclear Engineering. On average, I advise about 25 such students each semester. This process can be challenging at times. Working to find a way forward for students who have struggled during their first semesters, students who came to Missouri S&T without the necessary background in mathematics, and trying to help them succeed can be both trying and time consuming. But it is also very rewarding. Seeing those students get back on track and watching them succeed – and knowing that I was a part of that – is very gratifying. It also allows me to get to know many of the students before they even join the Nuclear Engineering program. I try to spend a few minutes each semester talking with the students about their performance, goals, and plans – this lets me help them with advice on which faculty to talk to about getting involved in research, which internships are available, and so on. On a professional level, it helps me identify students that I would like to target for recruitment as undergraduate researchers, LEAD peer helpers or teaching assistants, and possible future graduate students.

As part of my Freshman Engineering advising I was asked to work with Educational Technology to create a short introductory video. After discussing their intent with the Freshmen Engineering Program and meeting with EdTech I prepared a script and worked with them to record the video, which they then edited. I also suggested that Educational Technology get in touch with several current and former students for short interviews. I suggested a list of possible students and interview questions. The result was a short video of students giving their perspective on the Nuclear Engineering Program – a perspective that incoming Freshmen should find very valuable. The videos were so successful that the Program Chair for Nuclear Engineering is adding them to the program web page.

Department Committees

I have also been serving on a number of key department/program committees. The list of these committees can be found in Appendix A. Again, the selection of these committees reflects my conviction that service should be forward-looking and strategic.

One of the first committee assignments I requested was the Nuclear Engineering Program Curriculum Committee. This is the committee that reviews our student feedback and ABET metrics each year and recommends changes to continuously improve the curriculum. As part of this committee I completely re-designed our senior exit survey after reviewing the exit surveys of various other departments within the university and nuclear engineering programs at other universities. The new survey gives us a much better idea what our students did and did not like about their experience and provides additional data regarding key ABET metrics. This committee assignment also gives me the ability to suggest and argue for changes that I think are necessary to keep our program competitive in the national and global market. As a result of my efforts I was asked to serve as committee chair in Fall of 2016, a post I accepted.

I also requested to be assigned to the Nuclear Engineering Steering Committee, which was charged with updating the program strategic plan. In the program’s previous strategic plan, last updated in 2010, one of the key goals was to reach 160 students by 2020. We achieved that goal in
2015, reaching a total of 164 students that year. Due to our program’s strong growth during that period new challenges have arisen. Thus the steering committee was asked to take a fresh look at the program’s situation and develop new goals for the next five to ten years. That process has been complicated by the search for a new Mining and Nuclear Engineering Department Chair, and is ongoing.

On that note, I also requested to be assigned to the search committee for the new Mining and Nuclear Engineering Department Chair. I viewed this as a key opportunity to have a strong voice in the selection of the individual who will lead our department for the foreseeable future. It was a valuable learning experience. I was able to see first-hand many key university functions and meet a number of interesting people. I hope that some of the candidate interviews may lead to future research collaborations – I have ideas for collaboration with at least one of them. The committee members had some very valuable discussions on ways that the Mining Engineering, Explosives Engineering, and Nuclear Engineering programs can work more closely together in research, teaching, and service. As a result of those discussions, I have prepared a proposal that I will be presenting to the faculty detailing eight ways that I think we can work together to improve the department as a whole. The process was complicated by interference from very vocal alumni and other outside influences, but I believe that we selected to very qualified finalists over a period of five months. Overall the process was very rewarding.

In the next several years I plan to continue this strategic selection of service activities in order to continue to have an impact on the Nuclear Engineering program, our department, and the university.

**PROFESSIONAL SOCIETIES AND JOURNALS**

Service in professional societies and journals is one of the most effective ways to increase personal and institutional visibility. Professional organizations and conferences provide the opportunity to present your work, receive feedback from other experts, share knowledge, and build collaborations and partnerships.

**Journals**

I am an active reviewer for nine professional journals related to nuclear engineering and multiphase flow. Over the last two years I have completed 15 reviews for those journals. This has given me the chance to review current research in my field, get ideas for research topics, and identify possible collaborators. In addition to this, it has allowed me to establish myself in an expert in the field with valuable viewpoints. This is illustrated by the review request I have included in Appendix B, which identifies me as a “world leading expert in this technical area” and acknowledges my previous review activity.

**Professional Societies and Conferences**

I am an active member of both the American Nuclear Society and the Atomic Energy Society of Japan. The American Nuclear Society is the premier professional organization for those
involved in nuclear science and technology across the world, and sponsors multiple professional conferences each year. I am a member of the Thermal Hydraulics Division, which focuses on thermal-fluids research and teaching, and the Young Members Group, which is composed of those who have received their terminal degree within the last five years. This membership has helped me maintain contacts with the various students and professionals that I have met and worked with as a graduate student, postdoctoral researcher, and faculty member. I joined the Atomic Energy Society of Japan due to my strong research collaborations in that country, including previous work with Mitsubishi Heavy Industries, the Kyoto University Research Reactor Institute, and the Institute for Nuclear Safety Systems. This has allowed me to keep up on key research across all specialties of nuclear engineering and has helped strengthen those research ties.

I have also been active in professional conferences. Over the last year I have served as a reviewer for three conferences, reviewing five manuscripts. I attended two of those conferences and served as a session chair during NURETH 16, one of the most popular conferences on nuclear reactor thermal hydraulics in the world, with representatives from Japan, China, India, South Africa, and many European nations.

**SERVICE TO THE COMMUNITY**

Community service is an often-neglected component to professional service, but it is also important due to its uniqueness. Community service allows us to work with other members of the community – people we would not generally meet during our professional work. It allows us to spread the discussion of our research and educate people who are not experts in our field and – truthfully – may not be technical professionals at all. It allows faculty to increase their visibility in the community and build up the reputation of the university and the departments, and it allows faculty to pursue interests outside of their research and teaching.

For my part, I have long had an interest in theater. This is, in part, why I often view teaching as performance art. I have volunteered to serve community theaters in a technical capacity, as master electrician and lighting designer, for a number of years prior to moving to Rolla. During that time I set up lighting for five major musicals and at least a dozen more minor shows. For one of those musicals and three of the minor shows I was also the lighting designer, planning how each scene of the show would be lighted to produce the desired emotional and dramatic effect for the audience. I found both experiences to be extremely rewarding.

I have also had the opportunity to serve as a volunteer coordinator for HorrorHound Weekend. HorrorHound Weekend is a convention held twice each year, in Indianapolis, IN and Cincinatti, OH, to celebrate thriller and horror movies. Actors from various films and franchises are invited, along with special-effects artists, directors, and other professionals. People from all walks of life attend to meet celebrities and have fun. As part of the show my responsibility was to schedule volunteers at the various duty stations and make sure they got there, then make sure that they had the resources they needed to do their jobs. The experience was a lot of fun for me.

Through these admittedly unique activities, I was able to learn a great deal about performance and met many interesting people. And of course, when they found out that I was a
nuclear engineer, I had the opportunity to *discuss my field, my research and the university* with those people. Unfortunately I have not had the opportunity to continue these efforts over the last year for personal reasons, however in the next two to five years I hope to renew my involvement in these activities.
APPENDICES
APPENDIX A – CURRICULUM VITAE

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EDUCATION
Ph.D. in Nuclear Engineering, Purdue University (December 2012)
Thesis Title: Multidimensional Two-Phase Flow in Large Diameter Systems
Advisor: Distinguished Prof. Mamoru Ishii
M.S. in Nuclear Engineering, Purdue University (May 2009)
Thesis Title: Experimental and Analytical Study of Relative Velocity and Drag Force in Large Diameter Pipes
Advisor: Distinguished Professor Mamoru Ishii
B.S. in Nuclear Engineering, Purdue University (May 2007)

CURRENT POSITION
Assistant Professor, Department of Mining and Nuclear Engineering, Missouri S&T (March 2014 – Present)
• Teach courses in Nuclear Engineering
  o Reactor Fluid Mechanics (Nuc Eng 3221)
  o Reactor Heat Transfer (Nuc Eng 3223)
  o Nuclear Systems Design I/II (Nuc Eng 4496 and 4497)
  o Introduction to Nuclear Thermal Hydraulics (Nuc Eng 4257/5257)
  o Advanced Nuclear Thermal Hydraulics (Nuc Eng 6257)
• Research in two-phase flow, heat transfer, and reactor safety
  o Establishment of Thermal Hydraulics Experiment and Modeling for Energy applications (THEME) laboratory at Missouri S&T
  o Interfacial area transport measurement in large-diameter systems
  o Two-fluid model code development with interfacial area transport; bubble coalescence and breakup phenomena
  o Hydrodynamic models in CFD codes
  o Development of advanced two-phase flow instrumentation
  o Advanced light water reactor safety and passive safety systems; condensation heat transfer in Small Modular Reactor (SMR) safety systems
  o Development and assessment of phase change materials

OTHER PROFESSIONAL EXPERIENCE
Postdoctoral Fellow, School of Nuclear Engineering, Purdue University (2012 – 2014)
• Prepared proposals for funding of experimental research and reports for sponsors detailing results
• Provided grammatical review of reports prepared by other students prior to submission
• Scaled, designed and assembled experimental facilities, developed computer scripts for data collection and data processing and analysis, performed experiments and analyzed and interpreted data
• Worked with members of project teams to complete project deliverables in a timely fashion
• Created reports regarding experimental results and papers for submission to peer-reviewed journals
• Administered laboratory, maintained laboratory areas, scheduled safety training for laboratory personnel, maintained safety documentation and updated safety-related materials regularly
• Mentored and advised students as appropriate, assisted with formal teaching in areas of expertise
• Developed dynamic solver for interfacial area transport and void transport equations, coupled with prediction of pressure drop and gas velocity based on the two-fluid model
• Directed development of droplet-capable conductivity probes for local measurements in annular flow
GK-12 Teaching Program (August – December 2011)

- Assisted middle school teacher in the classroom one day per week, progressing to co-teaching and fully teaching the class based on lesson plans prepared by the teachers
- Developed a lesson plan related to field of study and used lesson plan to teach a class
- Participated in workshops to demonstrate instruction techniques and lesson plan development

Graduate Research Assistant, School of Nuclear Engineering, Purdue University (2007 - 2012)

- Prepared proposals for funding of experimental research and reports for sponsors detailing results
- Scaled, designed and assembled experimental facilities, developed computer scripts for data collection and data processing and analysis, performed experiments and analyzed and interpreted data
- Worked with members of project teams to complete project deliverables in a timely fashion
- Created reports regarding experimental results and papers for submission to peer-reviewed journals
- Developed new flow regime transition criteria and drift-flux constitutive relation for large diameter pipes to improve void fraction prediction in TRACE code (US NRC), updated previous models for interfacial area transport in large diameter pipes
- Developed new crossed-wire impedance meter design as an inexpensive, rapid alternative for evaluating the symmetry of two-phase flows. Travelled to Japan to train sponsor engineers in the use of the instrumentation (Mitsubishi Heavy Industries)
- Developed a high-speed multiple-probe technique for reducing the measurement time required for interfacial area concentration measurement using conductivity probe methods, including the use of advanced computer-controlled positioning systems and high-data-rate acquisition circuitry
- Performed experimental measurements of void transport in ECCS suction piping for PWR safety systems to evaluate safety implications relating to Generic Letter 2008-1 (Westinghouse Owners Group).
- Provided grammatical review of reports prepared by other students prior to submission

Undergraduate Laboratory Assistant, School of Nuclear Engineering, Purdue University (2006 – 2007)

- Assisted in preparation of project proposals, design of safety components and performance of experiments
- Developed computer scripts for data processing and analysis
- Assisted in data analysis and interpretation and preparation of reports for research sponsors
- Provided grammatical review of reports prepared by other students prior to submission

Resident Assistant, Tarkington Hall, Purdue University (2006-2007)

- Supervised a floor of 46 undergraduate students
- Created, planned, and implemented educational and social programs for residence
- Counseled students on academic and personal concerns
- Managed administrative duties including maintenance requests, incident reports, and room condition reports
- Enforced Residential Life rules and regulations to ensure a safe and enjoyable environment for living and studying

Student Supervisor, Pappy’s Sweet Shop, Purdue University (2004-2006)

- Supervised shifts of up to 8 student workers; assigned duties and tasks and ensured satisfactory completion
- Addressed customer complaints and concerns
- Ordered necessary supplies
- Prepared meals, took customer orders, ensured cleanliness
- Developed high-efficiency stocking system that allowed me to manage the entire kitchen alone on evenings and weekends

Student Worker, Hilltop Apartments (2005-2006)

- Responsible for all landscaping activities – planning and planting flower beds, tree care, etc.
- Repainted and performed minor maintenance on university-owned apartments
- One of two students retained for academic year after end of seasonal summer work

Seasonal Student Worker, Greenscape Landscape and Lawn Care (2003-2004)

- Responsible for unsupervised completion of lawn care contracts
- Constructed retaining walls, one-hole golf course, Japanese rock garden, and other projects
- Operated heavy equipment including dump trucks, Gehl/Bobcat lifts, and front-end loader
RESEARCH

RESEARCH SUMMARY

All university-level research programs have certain common goals: discovering new knowledge, integrating that knowledge with what we already know to achieve a deeper understanding of the world around us, applying knowledge to make the world a better place, and teaching that knowledge to others so that they can continue the process. Within that framework, my research has been focused on the application of the principles of heat, mass, and momentum transfer to nuclear reactor systems. My long-term goal is to become a nationally and internationally recognized expert in multiphase flow processes, specifically in the improvement of nuclear reactor performance and safety and energy efficiency. I plan to accomplish this goal by:

- Improving our scientific understanding of key phenomena important to industrial applications
- Applying fundamental principles to develop, evaluate, and refine models
- Validating those models using high-quality experimental measurements and innovative techniques
- Mentoring PhD candidates to produce qualified, creative faculty to continue developing the field

In pursuit of these goals I have brought $192,500 in research funds to Missouri S&T over the last two years. In addition I have been co-PI on two proposals to provide undergraduate scholarships to Missouri S&T students. Both proposals were funded by the U.S. Nuclear Regulatory Commission (US NRC), and my share of that funding is an additional $160,000. I have published a total of 22 papers in peer-reviewed journals with two more under review. Six of those publications have been produced this year. Perhaps more important than publishing is making sure that people are reading and using the work. Based on data obtained from my Google Scholar profile, I have a total of 202 citations (198 since 2011), an h-index of 8, and an i10-index of 7. The number of citations/year has been steadily increasing.

Also important is the development of a national and international reputation for excellence. I have already begun to develop such a reputation. I have developed collaboration with Dr. Xuizhong Shen, a researcher at the Kyoto University Research Reactor Institute in Japan. I have been approached by the Institute of Nuclear Safety Systems, a subsidiary of the Kansai Electric Power Company in Japan, to perform funded research on reactor safety analysis codes and model development. As a graduate student I travelled to Japan to train engineers at Mitsubishi Heavy Industries in the use of key instrumentation that I developed for them. I have fielded requests for information and assistance from researchers in various fields – from magma flows in volcanoes to gas/oil flows in oil drilling applications - and nations from the US to China to India to Russia.

The first step in the scientific method is observation – the collection of experimental data, and a key part of creating new knowledge. Experimental data is also intimately involved in testing hypotheses (models) that are developed to explain those observations. To that end, I have performed a great deal of experimental work over the course of my career. These experiments have relevance in a wide range of systems. At the NRC this includes establishing the Thermal Hydraulics Experiment and Modeling for Energy applications (THEME) laboratory at Missouri S&T. I have also been part of the development of advanced two-phase flow instrumentation. As a graduate student I developed a computer-controlled electronic positioning system capable of positioning void probes inside of a flow channel to within 0.1 mm precision. I then combined this with a multiple-void-probe system and a high-capacity data acquisition system in order to perform complex experiments in 15-20 minutes that previously required 3-4 hours. I am currently working with researchers at Purdue University and Bettis Atomic Power Laboratory to develop a void probe capable of measuring droplets and differentiating them from the continuous using a multiple-sensor electrical resistivity probe.

The next steps of the scientific method are developing hypotheses, testing hypotheses, and revising hypotheses. As part of this work I have developed new flow regime maps and drift-flux models in large diameter tubes. The
publication that resulted from this work became one of the 10 most-cited papers in the journal Progress in Nuclear Energy from 2010 to 2014. The centerpiece of this research has been the development of a one-dimensional two-phase flow analysis code using MATLAB. Based on the two-fluid model with a two-bubble-group approach for void transport and bubble coalescence and breakup, all of the constitutive models within the code are modular. I have also developed an objective optimization technique for two-phase flow models using principles from Pareto optimization and implementing a modified form of the Gauss-Newton algorithm.

My interest in enhancing passive safety in nuclear reactor systems is driven by the rise of small modular reactor (SMR) systems. The design of these systems lends them to various passive safety systems. One application is the use of Phase Change Materials (PCMs) in SMRs. I hope to design PCM systems that change phase in the temperature range of 90°C to 300°C and can be incorporated into the emergency core cooling systems of modern reactor systems. This has the potential to reduce the containment pressure and extend the time during which key safety systems are able to operate. I have begun this work by investigating room-temperature PCMs. While this is a first step in a larger research program, it also has important potential impacts. Heating and cooling comprises as much as 24% of the energy consumed in the United States each year. The use of PCMs can reduce energy consumption in this area by 30% to 50%, reducing energy costs and greenhouse gas emissions. Recently, my research team developed a novel eutectic PCM using naturally occurring fatty acids that has a melting temperature of 25.5°C and a heat of fusion of 205.2 kJ/kg. To improve the thermal conductivity of the PCM we incorporated graphene nanoplatelets into the PCM. This did not alter the melting temperature, but resulted in an increase of as much as 100% in the thermal conductivity of the PCM. The final energy storage capacity of the mixture is about 180 kJ/kg, comparable to other PCMs.

In addition to fundamental scientific and engineering work, I have been involved in a number of important applied research projects for a variety of sponsors. I created a dynamic solver for droplet behavior for Mitsubishi Heavy Industries on a project related to the design of a chemical scrubber for coal power applications. The solver was able to calculate the droplet fraction and determine the conditions for which instability due to counter-current flow limitation would occur, allowing MHI to avoid these conditions and optimize their final design. This led to additional work from that sponsor including the development of an impedance void meter capable of quickly evaluating the symmetry of the void fraction profile in a pipe. At the culmination of the project I travelled to their testing facility in Japan to assist in the installation and calibration of the instrument and train several of their engineers in its use. The technology was used to evaluate the effect of upstream conditions on pump degradation due to void ingress, leading to better guidelines for designing and operating emergency core cooling systems in nuclear reactor systems. That project was closely related to work that I did for Westinghouse Nuclear regarding air ingress in emergency core cooling systems. Over three years I worked on the design, construction, and testing of four scaled experimental facilities designed to mimic the behavior of emergency cooling pump systems. The results were used by Westinghouse Nuclear to justify the safety of the systems to the NRC. More recently I was the PI on a project for the Institute of Nuclear Safety Systems (INSS), a subsidiary of the Kansai Electric Power Company in Japan. This project involved evaluation of existing data and models for boiling in nuclear reactor cores and the recommendation of a transition model to bridge well-known conditions at nearly atmospheric pressures and at full-pressure operating conditions. This moderate-pressure region is important for the prediction of small-break loss of coolant accidents and reactor startup. I am also a co-PI on a project for the Small Modular Reactor Research and Education Consortium (SMRrec). This project involves the design and construction of a test facility to investigate scaling effects on condensation heat transfer in SMR passive cooling systems. Experimental data collection, analytical modeling, and computer simulation will be performed to evaluate the ability of current models to predict steam condensation heat transfer rates in the presence of non-condensable gases. The results will be used by the Consortium members in their licensing applications to the US NRC.
GRANTS AND CONTRACTS RECEIVED

Facility Integration for Synthesis and Testing of Nano-Radioisotopes at Missouri S&T
PI: Prof. Carlos H. Castaño Giraldo; co-PI: Dr. Xin Liu (30%), Dr. Joshua Schlegel (30%)
Period: --
Total Budget: $19,000 (Innovation at Missouri S&T)
Contribution:

Development of Improved Drift-Flux Model for Rod Bundles at Moderate Pressures
PI: Prof. Joshua P. Schlegel
Period: November 15, 2015 – February 5, 2016
Total Budget: $30,000 (Institute of Nuclear Safety Systems, Inc.)

Undergraduate Scholarships in Nuclear Engineering at Missouri S&T - II
PI: Prof. Hyoun-Koo Lee, co-PI: Prof. Joshua Schlegel (40%)
Period: August 1, 2015 – July 31, 2017
Total Budget: $200,000 (US NRC)
Contribution: Primarily responsible for preparing proposal and reports; serve on selection committee.

Experimental Validation of Models and Simulations in Nuclear Systems
PI: Prof. Joshua P. Schlegel
Period: February 1, 2015 – January 31, 2017
Total Budget: $55,000 (University of Missouri Research Board)

Undergraduate Scholarships in Nuclear Engineering at Missouri S&T
PI: Prof. Hyoun-Koo Lee, co-PI: Prof. Joshua Schlegel (40%)
Period: August 1, 2014 – July 31, 2016
Total Budget: $200,000 (US NRC)
Contribution: Primarily responsible for preparing proposal and reports; serve on selection committee.

Condensation Heat Transfer Experiment and Scaling
Co-PIs: Prof. Shaoib Usman (60%), Prof. Joshua P. Schlegel (40%)
Project Period: August 1, 2014 – June 30, 2015
Total Budget: $90,000 (SMR Research and Education Consortium)
Contribution: Primarily responsible for design and construction of test facility, performing experiments, and preparation of final report

Interfacial Area Transport Study in Gas-Dispersed Flow up to the Churn-Turbulent to Annular Flow Regime Transition
PI: Prof. Mamoru Ishii, Purdue University (75%); Prof. Joshua P. Schlegel, Missouri S&T (25%)
Project Period: August 1, 2014 – August 31, 2017
Total Budget: $619,000 (Bechtel Bettis Marine Propulsion)
Subcontract Budget: $33,000 (PI: Prof. Joshua P. Schlegel, Missouri S&T)
Contribution: Provide technical advice, primarily responsible for preparation of technical reports

Code Development for the Prediction of Bubble Coalescence and Breakup Rates in the Churn-Turbulent Flow Regime, Phase II
PI: Prof. Takashi Hibiki, Purdue University (25%); Co-PI: Prof. Joshua P. Schlegel, Missouri S&T (75%)
Project Period: April 1, 2014 – December 31, 2014
Total Budget: $120,000 (Chevron Energy Technology Company)
Subcontract Budget: $46,500 (PI: Prof. Joshua P. Schlegel, Missouri S&T)
Contribution: Performed all computational analysis and prepared final technical report

Code Development for the Prediction of Bubble Coalescence and Breakup Rates in the Churn-Turbulent Flow Regime
PI: Prof. Takashi Hibiki, Purdue University (25%); Co-PI: Dr. Joshua P. Schlegel (50%), Co-PI: Prof. Mamoru Ishii (25%)
Project Period: April 1, 2013 – December 31, 2013
Total Budget: $100,000 (Chevron Energy Technology Company)
Contribution: Developed MATLAB code, performed preliminary computational analysis and prepared final technical reports
PUBLICATIONS

https://scholar.google.com/citations?user=mhpWWK8AAAAJ&hl=en

Ph.D. Thesis

M.S. Thesis

Books and Book Chapters

Peer-Reviewed Journals

1 Research Advisee or co-Advisee

Invited Presentations


**TEACHING**

**TEACHING SUMMARY**

We do not evaluate faculty on how much they teach, but on how much their students learn. Those of us from academia have a long history of learning – and should therefore have a great deal of experience to draw upon. One of my best experiences as a learner was in my high school calculus and physics courses. What I remember most about those classes was the **sense of discovery** – the ‘aha!’ moments that occurred throughout the class. I realize now that those moments were the result of careful planning. That is what I hope to be able to do for my students, and I think that the students have gotten that message. Many of my student comments include some variation of “The most kind and caring professor I have ever had. He truly wants all of his students to succeed.”

During my time at Missouri S&T I have spent a lot of time trying to learn the best ways to achieve this goal. Being exposed to the idea of the **VARK learning inventory** was a powerful experience for me, and I began using it to design more varied instructional activities that would appeal to various learning styles. I also have the students fill out the inventory and learn more about their learning styles on the first day of class, which helps them develop study strategies for their other classes as well. One thing I have struggled with during my first years as an instructor is keeping students engaged with the material, as evidenced by some of the student comments. My introduction to **team-based learning strategies** has given me a new tool that I think will significantly improve student engagement in the classroom.

To move the students toward that ‘aha!’ moment, it is important to keep in mind the purpose of teaching. Why do we want to pass on what we know? The answer seems obvious, but is often lost in the noise of developing lesson plans, educational activities, and assessments. To me, the purpose of teaching is to (1) help students **understand the concepts and ideas** behind the equations and the real-world meaning of the facts that they can read in their textbooks, (2) give them the ability to **bring together the pieces of their education** and understand how they work together to describe real processes, (3) show them how to **use their existing knowledge and critical-thinking abilities** to develop new ideas, and (4) instill in students a **passion for learning and discovery**. These four goals should be the measuring stick for our success or failure as educators. How to go about achieving those goals is another matter entirely. I also believe that **people tend to rise or fall to the level that is expected of them**. I will admit to having very high expectations of our students, but I have found that once the students understand what those expectations are many of them rise to the challenge. I also believe that treating them like adults, with honesty and high - but realistic - expectations, allows them to treat themselves like adults and take the responsibility for their performance on themselves. One of my students commented “Very tough, made me push hard to earn a grade.” Another commented “Has high expectations but provides the tools to achieve them.”

There are some basic principles that I believe are very important to any attempt at education. The first principle is that teaching is a form of communication. In fact **teaching could be considered a form of performance art.** Vocal inflection, body language, humor – all of these factors communicate information to your audience. A good educator uses these nuances of communication to **convey passion and excitement** for the topic. I always make an effort to be an active speaker. It is also essential to know you audience and **adjust your teaching methods** to fit. I have used formal and informal mid-semester feedback to adjust my teaching techniques. As my students have said, “Dr. Schlegel was willing to improve on his teaching skills and in the way he taught constantly, which was one of his biggest strengths.”
It is also important to show students how the material they are learning has real-world applications and uses, and helps them to remember the information by connecting material to a memorable story or event as well as other important subjects. I have been working to improve this in my courses, and the students have noticed: “Keep doing examples. They were great!” Second, student participation is essential to learning. It requires the student to absorb and process the information immediately, rather than passively listening and writing notes. In-class activities and team-based learning focus student attention, keep them engaged, and help promote independent thinking. Third, students must have the opportunity to apply what they learn. For this reason I am also beginning to apply problem-based teaching techniques in the classroom. I use real-world examples, then have the students work in teams to come up with a recommendation to solve the real-world problem using the material we are discussing in class. Finally, we need to remember that learning should be fun. Learning is exploring the world around us in new ways. It is our responsibility to show students that even after decades of working in our fields we still enjoy our work and continue to discover new and interesting things.

At Missouri S&T my teaching responsibilities varied somewhat during my first few semesters. I have taught a total of nine different courses during my first seven semesters here. At this point I am responsible for four classes each year: Reactor Fluid Mechanics (NUC ENG 3221), Reactor Heat Transfer (NUC ENG 3223), Introduction to Nuclear Thermal Hydraulics (NUC ENG 4257/5257) and Advanced Nuclear Thermal Hydraulics (NUC ENG 6207). I also am co-teaching our capstone courses (NUC ENG 4496 and 4497), along with two other faculty, and have set up my graduate research credit (NUC ENG 6099) as a formal course. There have been many positive comments, as well as a few criticisms. One key criticism was that my exams were too long and were more difficult than other exams. However this was deliberate on my part. Unfortunately the experiment has not been successful, which contributed to overall effectiveness scores of 2.14 and 1.60 in my junior-level courses. I will be modifying this approach in the future. In my senior-level and graduate-level courses my overall effectiveness has been between 2.9 and 3.2.

The mentoring of graduate and undergraduate students is a key component of our efforts as university faculty. I have had one student complete a MS, and that student is continuing his work to obtain a PhD. I have one other student currently working toward a MS, and am advising 5 students in their PhD study. I expect my first two PhD graduates within two years. In addition, I have served/am serving on the advisory committees of many graduate students. This includes one student who is studying at Purdue University, where I was invited to be an outside member of his committee. I have an open-door policy – any time I am in my office the door is open, and students can stop in to discuss issues they are having. This is a lot of effort and is sometimes very inconvenient, but the students appreciate having that kind of access. I make sure to work with students on not only their scientific and technical skills, but also their professional development and communication skills. I hold group meetings for all of my graduate students every week to keep everyone updated on current research, progress, and goals. I assess the students each semester, and share the results of the assessment (including recommendations for addressing weaknesses) with the students. I encourage the graduate students under my supervision to seek out and attend professional development workshops – resume writing, interview skills, and so on - and attend career fairs and annual society meetings and conferences. In addition I make myself available to read and comment on their CV, discuss the interview process and answer any questions they may have. Finally, I emphasize the need for clear communication. I expect students to present to their peers each semester in a research group meeting and at least once prior to defending their dissertation through our department graduate seminar, and I work closely with them on writing the presentation and on their delivery skills. I also expect students to prepare manuscripts for publication, and take them through the process step by step from determining objectives and preparing an outline to writing the various sections and developing clear conclusions. I also encourage students to attend grant-writing workshops, then involve the students in helping me prepare proposals for funded research.
## GRADUATE STUDENT SUPERVISION

### Undergraduate Students

<table>
<thead>
<tr>
<th>Year</th>
<th>Student</th>
<th>Research Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>Christopher Lohff</td>
<td>Thermal Characterization of Nanofluids</td>
</tr>
<tr>
<td>2015</td>
<td>Sven Olberg</td>
<td>Evaluation of Phase Change Materials</td>
</tr>
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</table>

### M.S. Degrees Completed:

<table>
<thead>
<tr>
<th>Date</th>
<th>Student</th>
<th>Thesis/Dissertation Title</th>
<th>Current Position</th>
</tr>
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<tbody>
<tr>
<td>May 2016</td>
<td>Rami Saeed</td>
<td>Thermal Characterization of Phase Change Materials for Thermal Energy Storage</td>
<td>Research Scientist</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Phase Change Solutions, Inc.</td>
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### Degrees in Progress

<table>
<thead>
<tr>
<th>Degree</th>
<th>Student</th>
<th>Thesis/Dissertation Topic</th>
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</thead>
<tbody>
<tr>
<td>M.S.</td>
<td>Varun Kalra</td>
<td>Condensation Heat Transfer in Nuclear Reactor Safety</td>
</tr>
<tr>
<td>Ph.D.</td>
<td>Rami Saeed</td>
<td>Enhancement of Phase Change Materials</td>
</tr>
<tr>
<td>Ph.D.</td>
<td>Chandler Mills</td>
<td>Measurement of Interfacial Area Concentration</td>
</tr>
<tr>
<td>Ph.D.</td>
<td>Maria Camila Garcia Toro</td>
<td>Magnetically Aligned Carbon Nanotubes for Heat Transfer Enhancement in PCMs</td>
</tr>
<tr>
<td>Ph.D.</td>
<td>Jonathan Scott</td>
<td>Condensation Heat Transfer in Nuclear Reactor Safety</td>
</tr>
<tr>
<td>Ph.D.</td>
<td>Hayder Alnaseri</td>
<td>Bubble Dynamic Properties in Low Height Bubble and Slurry Bubble Column with Internals for Fischer-Tropsch Synthesis</td>
</tr>
<tr>
<td>Ph.D.</td>
<td>Palash Bhowmik</td>
<td>Undecided</td>
</tr>
<tr>
<td>Ph.D.</td>
<td>Ryan Steere</td>
<td>Undecided</td>
</tr>
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</table>

### Advisory Committee Service

<table>
<thead>
<tr>
<th>Degree</th>
<th>Date</th>
<th>Student</th>
<th>Thesis/Dissertation Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ph.D.</td>
<td>December 2015</td>
<td>Muhammad Yousaf</td>
<td>Study of Heat Transfer Phenomenon During Natural Convection</td>
</tr>
<tr>
<td>M.S.</td>
<td>May 2016</td>
<td>Maria Camila Garcia Toro</td>
<td>Production of Activated Gold Nanoparticles by Radiolysis</td>
</tr>
<tr>
<td>M.S.</td>
<td>May 2016</td>
<td>Jonathan Schattke</td>
<td>Accelerator-Driven Liquid-Metal Cooled Reactor System</td>
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<tr>
<td>M.S.</td>
<td>December 2016</td>
<td>Benjamin Prewitt</td>
<td>Analysis and Implementation of Accident Tolerant Fuels</td>
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<tr>
<td>M.S.</td>
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<td>Brandon Bringer</td>
<td>Non-Thesis</td>
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<tr>
<td>M.S.</td>
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<td>Raymond Fanning</td>
<td>Molten Salt Reactor</td>
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<td>Ph.D.</td>
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<td>Vineet Alexander</td>
<td>Hydrodynamics of Upflow Moving Bed Hydrotreating Reactor</td>
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<td>Ph.D.</td>
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<td>Athanas Mutiso</td>
<td>Out-Core 3D Fission Density Monitoring for SMRs</td>
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<tr>
<td>Ph.D.</td>
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<td>Vivek Rao</td>
<td>Numerical Investigation of Transient Thermal-Hydraulic Instabilities in a Small Modular Reactor</td>
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<tr>
<td>Ph.D.</td>
<td></td>
<td>Qingzi Zhu&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Droplet-Capable Conductivity Probe for Two-Phase Flow Measurements</td>
</tr>
</tbody>
</table>

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<sup>3</sup> Student at Purdue University
COURSES DEVELOPED AND TAUGHT

Undergraduate Courses

<table>
<thead>
<tr>
<th>Year Developed</th>
<th>Course Number and Title</th>
<th>Taught</th>
<th>Overall Effectiveness (4.0 scale)</th>
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<tbody>
<tr>
<td>--</td>
<td>NE 2105: Introduction to Nuclear Engineering</td>
<td>Spring 2014</td>
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<tr>
<td>--</td>
<td>NE 3221: Reactor Fluid Mechanics</td>
<td>Fall 2015 - Present</td>
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<tr>
<td>2015</td>
<td>NE 3223: Reactor Heat Transfer</td>
<td>Spring 2016 - Present</td>
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<tr>
<td>2015</td>
<td>NE 4257: Two-Phase flow in Energy Systems</td>
<td>Spring 2015 - Present</td>
<td>3.00</td>
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<td>--</td>
<td>NE 4496: Nuclear Systems Design I</td>
<td>Fall 2015</td>
<td>3.08</td>
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<td>NE 4497: Nuclear Systems Design II</td>
<td>Spring 2016</td>
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Graduate Courses

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<tr>
<th>Year Developed</th>
<th>Course Number and Title</th>
<th>Taught</th>
<th>Overall Effectiveness (4.0 scale)</th>
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<tbody>
<tr>
<td>2015</td>
<td>NE 5257: Introduction to Nuclear Thermal-Hydraulics</td>
<td>Fall 2015 - Present</td>
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<tr>
<td>2016</td>
<td>NE 6099: Advanced Topics in Nucl T-H</td>
<td>Fall 2014 - Present</td>
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<tr>
<td>2016</td>
<td>NE 6257: Advanced Nuclear Thermal-Hydraulics</td>
<td>Fall 2014 - Present</td>
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</tbody>
</table>

Course Descriptions

NUC ENG 3221: Reactor Fluid Mechanics
This course is an essential fluid mechanics course focused on teaching fundamental concepts and applications in fluid mechanics with a focus on nuclear reactor applications. The course is taught using a team-based approach that emphasizes critical thinking, translating problem statements into mathematical models, and engineering decision-making. Typically this course includes 35-40 students and is divided into six modules. Each module includes an introductory reading test, various team activities, individual homework, and an exam. Team activities are the focus of in-class time, while students are expected to obtain fundamental concept knowledge from the textbook and from short tutorial videos prepared by the instructor and posted on a YouTube channel.

NUC ENG 3223: Reactor Heat Transfer
This course is an essential fluid mechanics course focused on teaching fundamental concepts and applications in fluid mechanics with a focus on nuclear reactor applications. The course is taught using a team-based approach that emphasizes critical thinking, translating problem statements into mathematical models, and engineering decision-making. Typically this course includes 35-40 students and is divided into six modules. Each module includes an introductory reading test, various team activities, individual homework, and an exam. Team activities are the focus of in-class time, while students are expected to obtain fundamental concept knowledge from the textbook and from short tutorial videos prepared by the instructor and posted on a YouTube channel.

NUC ENG 4496: Nuclear Systems Design I
A capstone design course focused on combining knowledge from various specializations in nuclear engineering to prepare a design proposal for a nuclear system. Generally includes discussion of engineering ethics, engineering decision making, and engineering optimization. At the end of the course students prepare a preliminary design proposal and present their proposal to the class. Typically this course includes 35-40 students. This course was recently changed to a co-teaching format where multiple faculty share responsibilities in order to provide a wider range of expertise to the students.

NUC ENG 4497: Nuclear Systems Design II
The second semester of the capstone design course focused on combining knowledge from various specializations in nuclear engineering to prepare a final design report for a nuclear system. Content is focused on the various

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4 Most recent evaluation only
steps in the design process and is generally flexible to allow for variations in the needs of the design teams. At the end of the course students prepare a final design report and present their design to the class. Typically this course includes 35-40 students. This course was recently changed to a co-teaching format where multiple faculty share responsibilities in order to provide a wider range of expertise to the students.

NUC ENG 5257: Introduction to Nuclear Thermal Hydraulics
An introductory course for students interested in the application of fluid flow and heat transfer to nuclear reactor systems. Students will learn the fundamentals of the scientific method in engineering and review fundamental principles of mass, momentum, and energy transfer in nuclear systems. Modeling of single-phase flows and applications to energy systems will be discussed, as will fundamentals of heat transfer in nuclear fuels and reactor systems. The fundamental challenges of two phase flows and the field equations will be introduced with examples. Mixture properties and models, void fraction correlations, and pressure drop correlations for two-phase flows will be introduced, followed by a discussion of boiling and condensation. Typically includes 5-15 students.

NUC ENG 6099: Advanced Topics in Nuclear Thermal Hydraulics
A more formal version of research credit than is typical. Includes weekly student-led discussions of advanced research topics in nuclear thermal hydraulics, focusing on current research activities for each student. Topics include experimental techniques, data analysis, analytical modeling, computational modeling, paper writing, thesis/dissertation writing, research presentations, and analysis of the work of others. Each student is required to present their research to their peers, and each of the other students is required to ask at least one question at the end of the presentation. Also includes instructor-led discussions on professional-development topics (proposal writing, preparing resumes and CVs, interviewing, etc.).

NUC ENG 6257: Advanced Nuclear Thermal Hydraulics
Detailed treatment of advanced topics in nuclear thermal hydraulics including a brief introduction to PRA, fuel melting and severe accident scenarios, two-fluid modeling and interfacial area transport, counter-current flow limitation and flooding, etc.

SERVICE

SERVICE SUMMARY

Service should be just as forward-looking and strategic as research and teaching, if not more so. Service is a great way to increase visibility and make an impact on the future of the discipline, university, and department. It is a way to build strong professional relationships and develop partnerships. It is a vehicle for sharing knowledge and creating ideas. Since arriving at Missouri S&T I have worked to continue this philosophy. I have requested committee assignments that put me in a position to have a positive impact on the future of my department. Professionally, I have actively sought out reviewing assignments and been an active participant in highly visible professional conferences.

My departmental and institutional service has been focused on areas that will allow me to have a positive impact on the future. I have initiated some activities that do not fall under a committee – such as a review of the number of students, number of faculty, and key productivity measures for high-ranking Nuclear Engineering programs. The hope is that this process will help us identify areas that we can address to improve our impact and visibility. I make sure that I am available to help other committees when necessary and strive to be involved in departmental concerns and development. Much of this work is integrated with my every-day teaching and research activities. Along with Dr. Gary Mueller, I advise the students in the Freshman Engineering program who have indicated an interest in Nuclear Engineering. On average, I advise about 25 such students each semester. This summer (2016) I extended this role to help the Freshman Engineering Program produce an introductory video for Nuclear Engineering that has been included as part of FE 1100. I also suggested making a video with student responses to key questions of interest to incoming Freshmen, a suggestion that was then implemented. This was so successful that the Nuclear Engineering Program has included these videos on the program web page.

I have also been serving on a number of key department/program committees. One of the first committee assignments I requested was the Nuclear Engineering Program Curriculum Committee. This committee assignment
gives me the ability to **suggest and argue for changes that I think are necessary** to keep our program competitive in the national and global market. This fall (2016) I was asked to chair the committee, a post that I accepted. As part of this committee I completely **re-designed our senior exit survey** after reviewing the exit surveys of various other departments within the university and nuclear engineering programs at other universities. The new survey gives us a much better idea what our students did and did not like about their experience and provides additional data regarding key ABET metrics. I also requested to be assigned to the Nuclear Engineering Steering Committee, which was charged with updating the program strategic plan. Due to our program’s strong growth during the last decade new challenges have arisen. Thus the steering committee was asked to **take a fresh look at the program’s situation and develop new goals** for the next five to ten years. I also requested to be assigned to the search committee for the new Mining and Nuclear Engineering Department Chair. I viewed this as a key opportunity to have **a strong voice in the selection of the individual who will lead our department** for the foreseeable future. As a result of those discussions I prepared a proposal that I will be presenting to the faculty detailing eight ways that I think we **can work together to improve the department as a whole**.

Service in professional societies and journals is one of the **most effective ways to increase personal and institutional visibility**. Professional organizations and conferences provide the opportunity to present your work, receive feedback from other experts, share knowledge, and build collaborations and partnerships. I am an **active reviewer for nine professional journals** related to nuclear engineering and multiphase flow. Over the last two years I have **completed 15 reviews for those journals**. This has given me the chance to **review current research** in my field and to **establish myself in an expert in the field** with valuable viewpoints. I am an active member of both the American Nuclear Society and the Atomic Energy Society of Japan. The American Nuclear Society is the premier professional organization for those involved in nuclear science and technology across the world. I am a member of the Thermal Hydraulics Division and the Young Members Group. This membership has helped me **maintain contacts** with the various students and professionals. I joined the Atomic Energy Society of Japan due to my strong research collaborations in that country. This has allowed me to **keep up on key research** across all specialties of nuclear engineering and has helped strengthen those research ties. I have also been **active in professional conferences**. Over the last year I have served as a reviewer for three conferences, reviewing five manuscripts. I attended two of those conferences and **served as a session chair** during NURETH 16, one of the most popular conferences on nuclear reactor thermal hydraulics in the world, with representatives from across the world.

Community service is an often-neglected component to professional service, but it is also important due to its uniqueness. Community service **allows us to work with other members of the community** – people we would not generally meet during our professional work. It allows us to **spread the discussion** of our research and educate people who are not experts in our field and – truthfully – may not be technical professionals at all. It allows faculty to increase their visibility in the community and **build up the reputation** of the university and the departments, and it allows faculty to pursue interests outside of their research and teaching. For my part, I have long had an interest in theater. This is, in part, why I often view teaching as performance art. I have volunteered to **serve community theaters in a technical capacity**, as master electrician and lighting designer, for a number of years prior to moving to Rolla. During that time I set up lighting for five major musicals and at least a dozen more minor shows. For one of those musicals and three of the minor shows I was also the lighting designer, planning how each scene of the show would be lighted to produce the desired emotional and dramatic effect for the audience. I found both experiences to be extremely rewarding. I have also had the opportunity to serve as a volunteer coordinator for HorrorHound Weekend. HorrorHound Weekend is a convention held twice each year, in Indianapolis, IN and Cincinnati, OH, to celebrate thriller and horror movies. People from all walks of life attend to meet celebrities and have fun. As part of the show my responsibility was to schedule volunteers at the various duty stations and make sure they got there, then make sure that they had the resources they needed to do their jobs. The experience was a lot of fun for me. Through these admittedly unique activities, I was able to **learn a great deal about performance** and met many interesting people. And of course, when they found out that I was a nuclear engineer, I had the opportunity to **discuss my field, my research and the university** with those people. Unfortunately I have not had the opportunity to continue these efforts over the last year for personal reasons, however in the next two to five years I hope to renew my involvement in these activities.
PROFESSIONAL SOCIETIES
American Nuclear Society, 2005-Present
  Thermal Hydraulics Division, Young Members Group, 2014 – Present
  Purdue University Student Chapter, 2005-2012
  Outreach Committee Member, 2009-2011
  Graduate Representative, 2009-2011
Atomic Energy Society of Japan, 2015 – Present

AWARDS AND HONORS
Purdue University Outstanding Service Award, College of Engineering, Purdue University, 2011
US NRC Graduate Fellowship, 2010-2011
INPO Graduate Fellowship, 2007-2008
Alpha Nu Sigma (Nuclear Engineering Honor Society), 2007-Present
  Secretary (Purdue University), 2008-2009
Eagle Scout, Boy Scouts of America, 2001

PROFESSIONAL SERVICE
International Service
Reviewer
  Fluids – 5/17/16;
  International Journal of Multiphase Flow - 3/15/16;
  Chemical Engineering Science – 11/6/15; 1/13/16;
  Annals of Nuclear Energy – 10/1/13; 12/10/13; 7/17/14; 8/12/14; 10/31/16;
  Nuclear Engineering and Design – 7/6/15; 11/22/15;
  International Journal of Heat and Mass Transfer – 04/07/16; 07/18/16; 09/21/2016
  Nuclear Science and Engineering – 2/24/16;
  Sensors – 4/29/16; 8/1/16; 10/4/16;
  Applied Thermal Engineering – 8/29/16;
  11th International Topical Meeting on Nuclear Thermal Hydraulics, Operation and Safety (NUTHOS-11),
    October 9-13, 2016
  Reviewer
  2016 International Congress on Advances in Nuclear Power Plants (ICAPP-16)
    April 17-20, 2016
    Reviewer
  16th International Topical Meeting on Nuclear Reactor Thermal Hydraulics (NURETH-16)
    August 30 – September 4, 2015
    Reviewer; Session Chair

Missouri S&T
Nuclear Science Design Team Co-Advisor, 2015 – Present
MITE Summer Camp – Introduction to Nuclear Engineering Presentation, 2015 – Present

College of Engineering and Computing
CERTI Advisory Committee (2016 – Present)
  Resources subcommittee

Department of Mining and Nuclear Engineering
Freshman Engineering Program Academic Advisor for Nuclear Engineering, Missouri S&T, 2014 – Present
  Spring 2015 – 24 students; Fall 2015 – 27 students; Spring 2016 – 25 students; Fall 2016 – 35 students;
Nuclear Engineering NRC Scholarship Committee, Missouri S&T, 2014 – Present
Nuclear Engineering Program Curriculum Committee, Missouri S&T, 2015 – Present
  Chair: 8/2016 – Present
Nuclear Engineering Steering Committee, Missouri S&T, 2015 – Present
Nuclear Engineering Graduate Learning Outcomes Committee, Missouri S&T, 2015 – Present
Mining and Nuclear Engineering Chair Search Committee, Missouri S&T, 2015-2016
Purdue University
Nuclear Engineering Ambassadors, 2009-2012
School of Nuclear Engineering, Purdue University
College of Engineering/Graduate School Recruiter, 2010-2011
College of Engineering, Purdue University

COMMUNITY SERVICE
Lafayette Civic Theater; Lafayette, IN, 2012-2014
Lighting Designer and Master Electrician
HorrorHound Weekend; Indianapolis, IN, 2010-2014
Volunteer Coordinator
Hilltop Hall Council
Senator, 2003-2005
Vice President, 2005-2006
Service Learning, School of Foreign Languages, Purdue University, 2004
Student Union Board, Recreation Committee, 2003-2004
Sheboygan Theater Company; Sheboygan, WI, 2001-2004
Master Electrician

PROFESSIONAL DEVELOPMENT
Walk Through Promotion and Tenure
November 21, 2016; 4.5 Contact Hours
Scholarship of Teaching and Learning
November 7, 2016; 1.5 Contact Hours
University of Missouri Faculty Scholars Program
AY 2015-2016
Assessing Active Learning
April 8, 2016; 1 Contact Hour
Recruiting and Hiring a Diverse Workforce
March 16, 2016; 1.5 Contact Hours
Academic Advising Series: Advising 101
March 7, 2016; 1 Contact Hour
Academic Advising Series: Experiential Learning
February 15, 2016; 1 Contact Hour
Building Blocks: Structuring Your Course for Success
January 15, 2016; 5 Contact Hours
Academic Advising Series: Financial Aid 101
November 16, 2015; 1.5 Contact Hours
Freshman Faculty Forum
AY 2014-2015
Curator’s Teaching Summit, “Great Expectations: Bridging the Gap Between Instructor and Student Expectations”
September -December 2014; 4.5 Contact Hours
Getting Students to Focus on Learning instead of Grades
February 11, 2015; 1.5 Contact Hours
APPENDIX B – INFORMATION REQUESTS

Subject: Drift-flux question
From: Helge Gonnermann <helge@rice.edu>
Date: 9/15/2014 6:34 AM
To: <schlegelj@mst.edu>

Dear Dr. Schlegel,

I am working on the modeling of volcanic eruptions and am wondering to what extent you would recommend the use of drift flux theory in 1-dimensional models of magma ascent (H2O and CO2 vapor bubbles of 0.01 mPa.s viscosity in silicate melt of 10 Pa.s).

I am dealing with superficial gas velocities ranging between 0.1 to >10 m/s at superficial liquid velocities of 1 to >10 m/s, within the upper-most 500 m in volcanic conduits of about 10 m radius/diameter (presumably near cylindrical).

I have been struggling to ascertain whether there is sufficient experimental or theoretical basis, due to high viscosity and/or large conduit diameter, to justify applying drift flux theory to modeling flow in the upper 500 m in volcanic conduits.

Thank you very much for your help,
Helge Gonnermann

Assistant Professor
Department of Earth Science
Rice University

Subject: Request of paper copy
From: "Tikhonov, Vadim" <Vadim.Tikhonov@eu.weatherford.com>
Date: 4/4/2016 4:46 AM
To: "schlegelj@mst.edu" <schlegelj@mst.edu>

Dear Professor Joshua Paul Schlegel,

I, together with colleagues from Novosibirsk, am developing a models of the liquid-gas two-phase flow in vertical oil wells. I am very interested in your works on the development of drift-flux models for pipes of large diameter.

I'll be grateful to you if you send me a copy of your paper:

Schlegel P.J., Hibiki T., Ishii M., 2010, Progress in Nuclear Energy, 52...

Thanks a lot.

Yours sincerely,

Vadim Tikhonov
Subject: Reviewer Invitation for NED-D-15-00779
From: Nuclear Engineering and Design <ned@elsevier.com>
Date: 11/6/2015 5:59 AM
To: "Schlegel, Joshua P." <schlegel@mst.edu>

Ms. Ref. No.: NED-D-15-00779
Title: A Solver for the Two-Phase Two-Fluid Model Based on High-Resolution Total Variation Diminishing Scheme
Nuclear Engineering and Design

Dear Dr. Schlegel:

This paper presents a numerical scheme to solve the two phase two fluid thermal hydraulics equations with comparison with TRACE code and with claimed better accuracy. Given you are recognized as a world leading expert in this technical area, I would appreciate your review comments on this manuscript. I have included the abstract of the manuscript below to provide you with an overview.

I recognize you have performed excellent reviews for us recently. This could be an extra burden to you to review another manuscript for us within such a short time frame. However, your expertise is hard to come by and the quality of your previous review is highly recognized and appreciated. I have no choice but to invite you again so soon.

If you accept this invitation please let me know your acceptance in 12 days or sooner (not for finishing the review.) Yet, the actual due date for your review comments could be extended to 24 days. If you need more time to finish the review please let me know. Either way, I appreciate a response from you in time.

If you are unable to act as a reviewer at this time, I would greatly appreciate your suggestions for alternative reviewers.

Yours sincerely,

Jason Chao, Ph. D.
Editor
Nuclear Engineering and Design
APPENDIX C – SELECTED CITATIONS OF MY WORK


Besagni, G., G. Guedon, and F. Inzoli. 2014. Experimental Investigation of Counter Current


APPENDIX D – COURSE SYLLABI

NUC ENG 3221: Reactor Fluid Mechanics

REACTOR FLUID MECHANICS
NUC ENG 3221
T-Th 9:30-10:45
Toomey 254

INSTRUCTOR:
Dr. Joshua P. Schlegel
226 Fulton Hall
Tel: 573.341.7703
Email: schlegelj@mst.edu
Office Hours: Wednesday 9:00-11:00, Thursday 9:00-11:00 (or by appointment)

TEXT BOOK:

COURSE DESCRIPTION:
Learn to understand fluid mechanics problem statements involving incompressible viscous or inviscid flows. Translate those problems into a mathematical system: identify the appropriate control volume and control surface, then apply the balance equations, rate equations, simplifying assumptions, and boundary conditions. Solve the mathematical system, clearly communicate your results and be able to understand and discuss their significance. Topics include dimensional analysis, fluid statics, boundary layer theory, and applications to tube bundles. Focus on nuclear energy applications and nuclear reactors, including basic numerical methods.

COURSE OBJECTIVES:
1. Translate a problem statement into a mathematical model
   A. Identify the key information provided in the problem statement and identify the problem objective
   B. Create a conceptual sketch of the problem; Identify appropriate Control Volume(s) and Control Surface(s)
   C. List and define the key fluid mechanics properties including variables, dimensions, and units
   D. Identify appropriate balance equations and boundary conditions
   E. Identify and select appropriate simplifying assumptions

2. Identify and apply key fluids concepts
   A. Analyze systems using dimensional analysis to find the important dimensionless parameters for fluid systems
   B. Use the dimensionless parameters to validate assumptions and simplify problems
   C. Remember where to find detailed models and equations

3. Solve your mathematical model
   A. Calculate pressure distributions in static fluids
   B. Analyze boundary layer development
   C. Calculate head loss (pressure loss) in fluids systems
   D. Calculate the effects of fluid machinery including pumps, compressors, and turbines; Properly size fluid machinery for a given application

4. Clearly communicate your work
   A. Use a clear problem-solving method
   B. Discuss the significance of your analysis and results
      i. Explain the meaning and significance of your results in a wider context (extend beyond the scope of this course)
      ii. Compare and contrast with other problems
      iii. Examine your conclusions and summarize key observations
      iv. Criticize and evaluate the problem solving methods and discuss real-world applications and limitations

5. Develop confidence in the use of key skills in fluid mechanics

6. Learn to direct and enhance their own learning
   A. Identify learning style
   B. Identify strategies to improve learning based on learning styles
   C. Implement learning strategies to improve performance

7. Become productive members of a team
   A. Develop an appreciation of the value of working in project teams
8. Develop an appreciation for the importance of fluid mechanics in nuclear power system design and analysis

**What will students get out of this class?**

- Improved critical thinking abilities
- Ability to translate real-world problems into engineering models
- Ability to solve various kinds of fluid mechanics problems (even those they haven’t seen before)
- Better ‘engineering judgement’ regarding real-world applications (especially nuclear reactor behavior/analysis)
- Excitement about engineering problems
- Improved awareness of their own learning processes
- Improved ability to work on project teams

**GRADING POLICY:**
Final grades will be assigned as in Table 1. These grades will be a weighted average of exam and homework scores, with the weights given in Table 2.

**Table 1: Final Grade Assignments**

<table>
<thead>
<tr>
<th>Performance in the Class</th>
<th>Guaranteed Minima</th>
<th>Expected Curve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent Performance in the Class</td>
<td>A 85-100</td>
<td>70-100</td>
</tr>
<tr>
<td>Good Performance in the Class</td>
<td>B 75-84</td>
<td>60-69</td>
</tr>
<tr>
<td>Acceptable Performance in the Class</td>
<td>C 56-74</td>
<td>50-59</td>
</tr>
<tr>
<td>Poor Performance in the Class</td>
<td>D 50-64</td>
<td>35-49</td>
</tr>
<tr>
<td>Failed to Meet the Minimum Class Requirement</td>
<td>F 0-49</td>
<td>0-34</td>
</tr>
</tbody>
</table>

**Table 2: Final Grade Weighting**

<table>
<thead>
<tr>
<th>Item</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Readiness Assessment Quizzes</td>
<td>10%</td>
</tr>
<tr>
<td>Team Peer Evaluations</td>
<td>15%</td>
</tr>
<tr>
<td>Team Homework</td>
<td>15%</td>
</tr>
<tr>
<td>Exams (3)</td>
<td>60%</td>
</tr>
</tbody>
</table>

In addition, you will have the chance to evaluate the instructor. Following each exam, you will have the opportunity to fill out a review of the instructor’s performance and provide comments and suggestions for improving the course.

**HOMEWORK AND EXAMS:**
Homework will be due in class one week from the date it is assigned. It will be turned in to the instructor at the beginning of the class period. Late homework will not be accepted. All homework will be completed and turned in in cooperation with your team members (one homework submitted per team).

Homework grading:
- Each homework will be worth 100 points.
- 20 points will be awarded for formatting, listed below. As engineers, communicating our work is essential or it doesn’t do anyone any good.
- Each homework will consist of four problems worth 25 points each: one multi-part short answer problem on key concepts and definitions and three in-depth, forward-looking engineering problems.

Homework requirements (also useful for exams):
- Use engineering paper or plain white paper (NOT lined notebook paper). Use a separate sheet for each problem. Staple multiple pages. The instructor is not responsible for missing pages. (5 points)
- Include your name, class number, and assignment in the header of **each page**. Also include the page number of each page for assignments with multiple pages. (5 points)
- **Write legibly** and large enough to read clearly. Work that cannot be read/followed will not receive points. **Work neatly.** Follow the problem-solving method discussed in class. If necessary, include a **neat** sketch of
the problem. Solve the problem in an organized, logical fashion. Illegible handwriting or sloppy work WILL result in lost points! (10 points)

- **Show** all your work to receive all the credit.
- Clearly indicate your answer. Make sure your answer includes appropriate units.

**Homework tips:**

- Be mindful of **significant digits**.
- Always double-check your **units and conversions**. You can often work out how to solve a problem just by looking at the units, and mistakes in your work can often be found by checking the units of your solution against the expected units.
- Make sure to read the problem carefully, and answer the question correctly.

**Exams:**

- Exams will be given in class.
- An equation sheet will be provided for each exam. The equation sheet will be included in the exam and posted on Blackboard prior to the exam. I don’t expect memorization; I expect that you will understand how to use the equations.
- Bring a calculator for the exams.

**BLACKBOARD:**
Lecture presentations, homework assignments, supplemental material, and grades will be posted on Blackboard in a timely fashion. Please note that the lectures do not contain all of the necessary information, so these files are not a substitute for attending lectures. Follow your progress on Blackboard, and speak to the instructor if you believe a grade was reported incorrectly or if you are concerned about your progress. Make sure to bring in your graded work if you believe a grade was reported incorrectly.

**ATTENDANCE AND PARTICIPATION:**
Participation in class, and therefore attendance, is important to developing the skills necessary to succeed in any course. Not all of the important material will be included in the presentation slides; a good deal will be presented and discussed only in class. That said, attendance will not be taken in this class. You are responsible for your own attendance. If you must miss class for some reason (other coursework, family emergency, sick, etc) please inform the instructor prior to, or as soon as possible after, the missed class to make arrangements related to missed material.

It is expected that you will be respectful during class periods. Please keep outside distractions to a minimum. Do not engage in side conversations with other students. Electronics in the classroom are encouraged, but don’t let them become a distraction. Keep cell phones and tablets on silent.

**ACADEMIC DISHONESTY:**
A student enrolling in the University assumes an obligation to behave in a manner compatible with the University's function as an educational institution. Page 33 of the Student Academic Regulations handbook describes the student standard of conduct relative to the System's Collected Rules and Regulations section 200.010, and offers descriptions of academic dishonesty including cheating, plagiarism or sabotage (http://registrar.mst.edu/media/administrative/registrar/documents/academicregulations/academic regulations 2014-2016.pdf). Please review the Student Academic Regulations in the address above. Plagiarism, cheating, and other forms of academic dishonesty will result in a failing grade for the assignment and possibly the course.

The student council honor code can be found at http://stuco.mst.edu/about/honor.shtml. The honor code highlights two important topics: honesty and respect.

**DISABILITY SUPPORT SERVICES:**
Any student inquiring about academic accommodations because of a disability should contact Disability Support Services so that appropriate and reasonable accommodative services can be determined and recommended. Disability Support Services is located in 204 Norwood Hall. Their phone number is 341-4211 and their email is dss@mst.edu.

http://dss.mst.edu
CONCERNS AND COMPLAINTS:
If there are concerns of complaints please talk to me and I will try to respond your worries and concerns. If you feel you cannot talk with me, please feel free to talk to the Department Chair, Dr. Hyoung-Koo Lee (leehk@mst.edu).

TITLE IX:
Missouri University of Science and Technology is committed to the safety and well-being of all members of its community. US Federal Law Title IX states that no member of the university community shall, on the basis of sex, be excluded from participation in, or be denied benefits of, or be subjected to discrimination under any education program or activity. Furthermore, in accordance with Title IX guidelines from the US Office of Civil Rights, Missouri S&T requires that all faculty and staff members report, to the Missouri S&T Title IX Coordinator, any notice of sexual harassment, abuse, and/or violence (including personal relational abuse, relational/domestic violence, and stalking) disclosed through communication including but not limited to direct conversation, email, social media, classroom papers and homework exercises.

Missouri S&T’s Title IX Coordinator is Vice Chancellor Shenethia Manuel. Contact her directly (manuels@mst.edu; (573) 341-4920; 113 Centennial Hall) to report Title IX violations. To learn more about Title IX resources and reporting options (confidential and non-confidential) available to Missouri S&T students, staff, and faculty, please visit http://titleix.mst.edu.
**TENTATIVE SCHEDULE (subject to change):**

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Course Introduction</td>
<td>--</td>
</tr>
<tr>
<td>1b</td>
<td>Introduction to Fluid Mechanics</td>
<td>Chapter 1</td>
</tr>
<tr>
<td>2a</td>
<td>Introduction to Fluid Mechanics</td>
<td>Chapter 1</td>
</tr>
<tr>
<td>2b</td>
<td>Fundamental Fluids Concepts</td>
<td>Chapter 2</td>
</tr>
<tr>
<td>3a</td>
<td>Control Volume Laws</td>
<td>4.1-4.4</td>
</tr>
<tr>
<td>3b</td>
<td>Control Volume Laws</td>
<td>4.5-4.10</td>
</tr>
<tr>
<td>4a</td>
<td>Differential Analysis</td>
<td>5.1-5.4</td>
</tr>
<tr>
<td>4b</td>
<td>Computational Methods</td>
<td>5.5</td>
</tr>
<tr>
<td>5a</td>
<td>Dimensional Analysis, Exam 1 Review</td>
<td>7.1-7.4</td>
</tr>
<tr>
<td>5b</td>
<td>Exam 1</td>
<td>Chapters 1, 2, 4, and 5</td>
</tr>
<tr>
<td>6a</td>
<td>Dimensional Analysis</td>
<td>7.5-7.7</td>
</tr>
<tr>
<td>6b</td>
<td>Introduction to Fluid Statics</td>
<td>3.1-3.3</td>
</tr>
<tr>
<td>7a</td>
<td>Hydraulic Systems</td>
<td>3.4-3.8</td>
</tr>
<tr>
<td>7b</td>
<td>Euler's Equation and Bernoulli's Equation</td>
<td>6.1-6.4</td>
</tr>
<tr>
<td>8a</td>
<td>Bernoulli's Equation</td>
<td>6.5-6.8</td>
</tr>
<tr>
<td>8b</td>
<td>Boundary Layers</td>
<td>9.1-9.6</td>
</tr>
<tr>
<td>9a</td>
<td>Boundary Layers</td>
<td>9.1-9.6</td>
</tr>
<tr>
<td>9b</td>
<td>Friction and Drag</td>
<td>9.7-9.9</td>
</tr>
<tr>
<td>10a</td>
<td>Friction and Drag, Exam 2 Review</td>
<td>9.7-9.9</td>
</tr>
<tr>
<td>10b</td>
<td>Exam 2</td>
<td>Chapters 7, 3, 6, and 9</td>
</tr>
<tr>
<td>11a</td>
<td>Fully Developed Laminar Flow</td>
<td>8.1-8.3</td>
</tr>
<tr>
<td>11b</td>
<td>Flow in Pipes and Ducts; CFD Tutorial 2</td>
<td>8.4-8.7</td>
</tr>
<tr>
<td>12a</td>
<td>Solution to Pipe Flow Problems</td>
<td>8.8</td>
</tr>
<tr>
<td>12b</td>
<td>Flow Measurement</td>
<td>8.9-8.13</td>
</tr>
<tr>
<td>13a</td>
<td>Fluid Machinery</td>
<td>Chapter 10</td>
</tr>
<tr>
<td>13c</td>
<td>Fluid Machinery</td>
<td>Chapter 10</td>
</tr>
<tr>
<td>14a</td>
<td>Flow in Open Channels</td>
<td>11.4-11.4</td>
</tr>
<tr>
<td>14b</td>
<td>Flow in Open Channels</td>
<td>11.5-11.8</td>
</tr>
<tr>
<td>15a</td>
<td>Compressible Flow</td>
<td>Chapter 12, Chapter 13</td>
</tr>
<tr>
<td>15c</td>
<td>Exam 3</td>
<td>Chapters 8, 10, 11, 12, and 13</td>
</tr>
</tbody>
</table>
NUC ENG 3223: Reactor Heat Transfer

REACTOR HEAT TRANSFER
NUC ENG 3223
T-Th 12:30-1:45
IDE 105

INSTRUCTOR:
Dr. Joshua P. Schlegel
226 Fulton Hall
Office Hours: Wednesday 9:00-11:00, Thursday 2:00-5:00 (or by appointment)
Tel: 573.341.7703
Email: schlegelj@mst.edu

TEXTBOOKS:

COURSE DESCRIPTION:
Learn to understand heat transfer problem statements involving conduction, convection and thermal radiation. Translate those problems into a mathematical system: identify the appropriate control volume and heat transfer processes. Apply the balance equations, rate equations, simplifying assumptions, and boundary conditions. Solve the mathematical system. Clearly communicate your results and be able to understand and discuss their significance. Focus on nuclear energy applications and nuclear reactors, including basic numerical methods and CFD applications.

COURSE OBJECTIVES:
1. Translate a problem statement into a mathematical model and solve the problem
   A. List and Define the key heat transfer properties including variables, dimensions, and units
   B. Combine knowledge from previous courses – fluid mechanics, statics, differential equations, physics
   C. Identify appropriate Control Volume(s) and Control Surface(s)
   D. Identify and apply appropriate balance equations, simplifying assumptions, and boundary conditions
2. Identify and apply key heat transfer processes
   A. Remember and apply the fundamental rate equations: conduction, convection and radiation
   B. Remember the important dimensionless parameters for heat transfer systems and use them to simplify problems
   C. Remember where to find more detailed models
3. Solve your mathematical model
   A. Calculate heat flux by convection, conduction or radiation using the fundamental rate equations
   B. Evaluate whether systems are realistic
   C. Calculate the temperatures/temperature differences necessary for a given process to occur
4. Clearly communicate your work and understand its significance
   A. Use a clear problem-solving method
   B. Discuss the significance of your analysis and results:
      i. Explain the meaning of your results; Examine your conclusions and summarize key observations
      ii. Compare and contrast with other problems
      iii. Criticize and evaluate the methods and discuss real-world applications and limitations
5. Apply these principles to nuclear reactors systems
   A. Fuel conduction
   B. Internal and external fluid flows – Reactor cores and steam generators
   C. Volumetric radiation heating
GRADING POLICY:
Final grades will be divided into categories, as detailed in Table 1. The students will determine the weights associated with each of the categories during the first week of the semester. After the weights have been determined, the syllabus will be updated on Canvas. This grading system is designed to reward both individual effort and group effort.

Final grades will be assigned as detailed in Table 2. An ‘A’ grade reflects success on work that should challenge the top third of the class. A ‘B’ grade reflects success on work that should challenge the middle third of the class. A ‘C’ grade reflects success on work that should challenge the bottom third of the class. The instructor reserves the right to curve the grade distribution to reflect class performance and variations in the difficulty of exams and assignments.

Table 1: Grade Categories

<table>
<thead>
<tr>
<th>Subcategory</th>
<th>Weight</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual Work</td>
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<tr>
<td>Individual RATs (6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homework Assignments (12)</td>
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<td></td>
</tr>
<tr>
<td>Individual Exams (6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team Work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team RATs (6)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Team problem sets (done in class)</td>
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<td></td>
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<tr>
<td>Team Exams (6)</td>
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</tbody>
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Table 2: Final Grade Assignments

<table>
<thead>
<tr>
<th>Estimated Range</th>
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<tbody>
<tr>
<td>Excellent Performance in the Class</td>
<td>A 80-100</td>
</tr>
<tr>
<td>Good Performance in the Class</td>
<td>B 70-80</td>
</tr>
<tr>
<td>Acceptable Performance in the Class</td>
<td>C 60-70</td>
</tr>
<tr>
<td>Poor Performance in the Class</td>
<td>D 50-60</td>
</tr>
<tr>
<td>Failed to Meet the Minimum Class Requirement</td>
<td>F 0-50</td>
</tr>
</tbody>
</table>
COURSE STRUCTURE:
The basic idea of team-based learning is to use our valuable and limited time in class to focus on addressing areas of confusion, solidifying and expanding on basic concepts, and improving application knowledge. This is opposed to a traditional lecture class, where class time is used to impart content knowledge from the textbook or another source and students are left to develop their application knowledge on their own (see Fig. 1). This means that in a team-based learning course you (the student) are expected to develop your initial understanding of the material through your own effort (i.e. reading the text, taking notes, etc.). Then class time is used to fix the information in memory through repetition and to practice using the content knowledge to solve problems, rather than memorizing the knowledge.

This class will be making extensive use of teams. Teams are very different from groups. Our teams will be permanent (at least for the duration of the class). Team assignments during class will be competitions and debates among the teams. This idea is important, because a team working together can accomplish significantly more than individual members working together. A group is just several individuals working in the same direction; a team self-organizes to take advantage of its members’ strengths and shore up their weaknesses in order to move the team as a whole forward. This inspires a greater level of individual commitment and trust among team members. The team activities will foster repetition, promote individual accountability, encourage students to attempt more challenging problems, and develop students’ ability to function effectively on project teams.

The course will be organized into six modules. The structure of each module is illustrated using the ‘castle-top diagram’ in Fig. 2. Components in the bottom of the figure represent out-of-class work, while components in the top part of the figure represent in-class work. Students are responsible for preparing for each module by reading the assigned text and taking necessary notes. At the beginning of each module the class will spend one class period working through the Readiness Assurance Process (described below). The next class period will be spent in teams working through problems related to basic concepts. Following class periods will be dedicated to team-based work on problems of increasing complexity. Homework will be assigned during each module (typically one assignment on basic concepts and one on more complex problems). At the end of each module there will be a short examination.

Readiness Assurance Process
The Readiness Assurance Process is intended to test whether you are prepared for the in-class group activities and to provide practice recalling and using concepts from the module. To prepare for the Readiness Assurance Test (RAT) students should read the assigned chapter(s) from the text and, if possible, discuss them with their teams.

At the beginning of each RAT each team will be allowed to ask the instructor one question regarding the content of the module. This will be followed by the individual RAT. The RAT will be focused on key concepts and ideas rather than computations, and students may use their handwritten notes during the RAT. The individual RAT will last approximately 15 minutes.

At the end of the individual RAT students will place their individual tests in their team folders. Then we will take the RAT as a team. This team RAT will also last approximately 15 minutes. Again, students may use their handwritten
notes. When the team RATs are completed, we will spend about 20-30 minutes going over the answers to the RAT. Students and teams will be responsible for grading their own RATs and recording their scores in their team folders. Both individual and group RATs will be included as part of the final grade.

Finally, the remainder of the class period will consist of a mini-lecture. The content of this lecture will be determined by the questions that students had trouble with on the RATs, and will focus almost exclusively on topics that students were not able to understand adequately from the assigned reading.

The appeals process:
After the RATs are completed, teams may appeal the grade results. If a team believes their answer should have been correct they may submit up to a one-page (typed) appeal. The appeal should give the RAT number and question number, the ‘correct’ answer, the team’s answer, and why the team believes their answer should be counted as correct. If the team’s appeal is logically sound, the team (and all team members who had the same answer) will receive the points they missed. They will also receive four extra credit points on that RAT. If the appeal is unsuccessful, however, the team will lose four points from their RAT score. The appeals process is open-book.

Appeals are subject to the following limitations:
- Only one appeal may be submitted per team per RAT
- Appeals will only be accepted on questions that were missed by the team, not by an individual

In-Class Team Problems
Our in-class time will be spent working problems in teams. Teams will use the content from the text to answer progressively more complex problems. Typically these problems will require the team to make a decision or select

Figure 2: Course Module Structure
from among several options. They will be open-book, and the team’s final ‘answer’ will be reported on a short answer form and will include (a) their final decision, and (b) the key reasons for that decision. These short forms will be placed in the team folder and graded by the instructor.

At the end of each problem the teams will reveal their answers to the class. Any disagreements between the various teams will be addressed through inter-team discussions – thus the teams should be prepared to defend their decision!

The final group activity of each module in the course will be a content review. Students will be provided 5 minutes to review the content individually and identify areas that they are still struggling with. Then the teams will meet for 10 minutes to discuss those areas. During this time, teams should work on explaining these difficult concepts to each other. At the end of the 15 minutes, each team will be allowed to ask the instructor a single question.

**Homework**

Homework will be an individual grade. Each module will have two homework assignments. The first will be assigned the day of the RAT and will be due prior to the next class period. That assignment will cover key concepts and ideas from the reading, with some simple problems. The second assignment will be assigned during the second class of the module and will be due prior to the class before the module exam. This second homework assignment will consist of more complex, worked out problems.

Homework will be submitted in Canvas, in multiple-choice format. Grades will be available immediately, and students will be able to re-submit the homework once as an opportunity to re-work the incorrect problems and correct any mistakes that were made on the first submission.

**Examinations**

Exams in NUC ENG 3223 will also consist of two parts. First will be a 40 minute individual exam. This exam will take place during the final class period of each course module. The individual exam will be followed by a 30 minute team exam. The team exam will be identical to the individual exam. Both the individual and team exams will be closed-book and closed-notes and will focus on solving problems.

**Peer Evaluations**

Peer evaluations will be performed to evaluate each individual's contribution to their group’s success. The peer evaluation criteria will be determined by the students following the completion of the first course module. These criteria will then be incorporated into an online evaluation form.

In the peer evaluation process, each student will be allowed 100 points to assign to each of the other team members. Points should be assigned based on the degree to which each student fulfilled the criteria determined earlier in the class. The average score for each team will be 100 points. This represents average effort/effectiveness as a team member. Each team member will have their grade for group work modified by a factor \( a = \frac{\text{Peer evaluation score}}{100} \). That means a team member who obtains 110 peer evaluation points will be awarded a group score of 10% higher than the actual group score. Conversely a team member with 90 peer review points will be awarded a group score 10% lower than the actual group score. An example of this process is shown in Figs. 3 and 4. Any student scoring lower than 70 points for their peer review will automatically fail the course.

Please note that thoughtful responses on peer evaluations are necessary to keep individuals accountable for their contribution to your teams. Simply assigning everyone an ‘average’ score will hurt team members who contributed most and reward team members who do not contribute! Also note that failing to turn in your peer evaluation will result in your team members having an average score of approximately 80 points, drastically reducing their group work scores and final grades in the course!

A ‘practice’ peer review will be performed at the end of the second course module. This mid-semester feedback will allow students to see whether they are being effective team members, and allow teammates to provide them with constructive criticisms to enable them to be more productive team participants. The final, graded peer review will be performed during the last week of class.
Figure 3: Peer Review Scoring

<table>
<thead>
<tr>
<th>Member Evaluated</th>
<th>Amy</th>
<th>Bob</th>
<th>Carolyn</th>
<th>David</th>
<th>Eugene</th>
<th>Felicia</th>
<th>Sum of Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amy</td>
<td>X</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>100</td>
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<tr>
<td>Bob</td>
<td>21</td>
<td>X</td>
<td>22</td>
<td>21</td>
<td>19</td>
<td>22</td>
<td>105</td>
</tr>
<tr>
<td>Carolyn</td>
<td>22</td>
<td>23</td>
<td>X</td>
<td>22</td>
<td>23</td>
<td>20</td>
<td>110</td>
</tr>
<tr>
<td>David</td>
<td>17</td>
<td>20</td>
<td>18</td>
<td>X</td>
<td>19</td>
<td>21</td>
<td>95</td>
</tr>
<tr>
<td>Eugene</td>
<td>22</td>
<td>20</td>
<td>23</td>
<td>18</td>
<td>X</td>
<td>17</td>
<td>100</td>
</tr>
<tr>
<td>Felicia</td>
<td>18</td>
<td>17</td>
<td>17</td>
<td>19</td>
<td>19</td>
<td>X</td>
<td>90</td>
</tr>
<tr>
<td>Avg. rating</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>20</td>
<td>100</td>
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</tbody>
</table>

Figure 4: Group Grade Modification Based on Peer Review Scores

<table>
<thead>
<tr>
<th>Evaluator</th>
<th>Arnold</th>
<th>Betty</th>
<th>Calvin</th>
<th>DeeAnn</th>
<th>Everett</th>
<th>Sum of Ratings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arnold</td>
<td>X</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>100</td>
</tr>
<tr>
<td>Betty</td>
<td>25</td>
<td>X</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>100</td>
</tr>
<tr>
<td>Calvin</td>
<td>25</td>
<td>25</td>
<td>X</td>
<td>25</td>
<td>25</td>
<td>100</td>
</tr>
<tr>
<td>DeeAnn</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>X</td>
<td>25</td>
<td>100</td>
</tr>
<tr>
<td>Everett</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>X</td>
<td>100</td>
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<tr>
<td>Avg. rating</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>25</td>
<td>100</td>
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<table>
<thead>
<tr>
<th>Student's Name:</th>
<th>Carolyn</th>
<th>Points Earned</th>
<th>Total Points Available</th>
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<tbody>
<tr>
<td>I. Graded Work: Individual Items</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>A. Individual activity, #1</td>
<td>13</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>B. Individual activity, #2</td>
<td>13</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>C. RATs: Individual Portion</td>
<td>21</td>
<td>25</td>
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<tr>
<td>D. Term Paper</td>
<td>13</td>
<td>15</td>
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<tr>
<td>E. Final Exam</td>
<td>26</td>
<td>30</td>
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<tr>
<td>SUB-TOTAL “Individual Score”:</td>
<td>86</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>II. Graded Work: Group Items</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>A. Readiness Assurance. Tests: Group Portion</td>
<td>13</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>B. Mid-Semester Application Project</td>
<td>8</td>
<td>10</td>
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</tr>
<tr>
<td>C. Final Group Project</td>
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<td>25</td>
<td></td>
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<tr>
<td>Initial “Group Score”:</td>
<td>45</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

| Adjustment for Peer Evaluation: |        |               |                        |
| Initial Group Score             | 45      |               |                        |
| Carolyn’s Peer Evaluation Score (from Table B.2) | 110% |
| Adjusted Group Score (45 X 110%) | 49.5    |               |                        |

| Calculation of Carolyn’s Course Grade Points |        |               |                        |
| I. Individual Score               | 86.0    |               |                        |
| II. Adjusted Group Score:         | 49.5    |               |                        |
| TOTAL                           | 135.5   |               |                        |

Figure 4: Group Grade Modification Based on Peer Review Scores
Team Folders
Each team will be provided a team folders. These folders will be handed out to the teams at the beginning of each class period and will contain that day’s RAT, team problems, or exams. Completed work will be turned in to the instructor with the team folders at the end of the class period for grading/evaluation.

Each team folder will have a cover sheet. The cover sheet will be used to record the RAT scores for each team member using a numerical identifier (rather than the students’ names). This will provide each team with a quick idea of how the team and individuals are performing, and will also provide a quick performance comparison with the other teams.

Teams are encouraged to come up with creative (but appropriate) team names and may customize their team folder if they wish.

CANVAS:
Presentations, homework assignments, supplemental material, etc. will be posted on Canvas in a timely fashion. Homework assignments will be submitted through Canvas, and all pertinent course information will be posted including announcements, course discussion boards, etc.

ATTENDANCE AND PARTICIPATION:
Participation in class, and therefore attendance, is important to developing the skills necessary to succeed in any course. That said, attendance will not be taken in this class.

In the workplace, when someone is absent, the group has to pick up the slack but the absent member benefits from the group work. If the absent person has a good reason for being gone, explains that reason to the group, and does their best to make amends, most groups will be happy to extend that benefit. However if group members have doubts about the reason for the absence, feel like the team member is trying to freeload, or both, then the absence is not likely to be forgotten when it is time for peer evaluations. If you must be absent let your team and the instructor know in advance and make sure that you do your best to make up for it.

It is expected that you will be respectful during class periods. Please keep outside distractions to a minimum. Do not engage in side conversations with other students. Electronics in the classroom are encouraged, but don’t let them become a distraction. Keep cell phones and tablets on silent.

ACADEMIC DISHONESTY:
A student enrolling in the University assumes an obligation to behave in a manner compatible with the University's function as an educational institution. Page 33 of the Student Academic Regulations handbook describes the student standard of conduct relative to the System's Collected Rules and Regulations section 200.010, and offers descriptions of academic dishonesty including cheating, plagiarism or sabotage (http://registrar.mst.edu/media/administrative/registrar/documents/academicregulations/academic_regulations_2014-2016.pdf). Please review the Student Academic Regulations in the address above. Plagiarism, cheating, and other forms of academic dishonesty will result in a failing grade for the assignment and possibly the course.

The student council honor code can be found at http://stuco.mst.edu/about/honor.shtml. The honor code highlights two important topics: honesty and respect.

DISABILITY SUPPORT SERVICES:
Any student inquiring about academic accommodations because of a disability should contact Disability Support Services so that appropriate and reasonable accommodative services can be determined and recommended. Disability Support Services is located in 204 Norwood Hall. Their phone number is 341-4211 and their email is dss@mst.edu.

http://dss.mst.edu
CONCERNS AND COMPLAINTS:
If there are concerns of complaints please talk to me and I will try to respond your worries and concerns. If you feel you cannot talk with me, please feel free to talk to the Department Chair, Dr. Hyoung K. Lee (leehk@mst.edu).

TITLE IX:
Missouri University of Science and Technology is committed to the safety and well-being of all members of its community. US Federal Law Title IX states that no member of the university community shall, on the basis of sex, be excluded from participation in, or be denied benefits of, or be subjected to discrimination under any education program or activity. Furthermore, in accordance with Title IX guidelines from the US Office of Civil Rights, Missouri S&T requires that all faculty and staff members report, to the Missouri S&T Title IX Coordinator, any notice of sexual harassment, abuse, and/or violence (including personal relational abuse, relational/domestic violence, and stalking) disclosed through communication including but not limited to direct conversation, email, social media, classroom papers and homework exercises.

Missouri S&T’s Title IX Coordinator is Vice Chancellor Shenethia Manuel. Contact her directly (manuels@mst.edu; (573) 341-4920; 113 Centennial Hall) to report Title IX violations. To learn more about Title IX resources and reporting options (confidential and non-confidential) available to Missouri S&T students, staff, and faculty, please visit http://titleix.mst.edu.
<table>
<thead>
<tr>
<th>Module</th>
<th>Week</th>
<th>Activities</th>
<th>Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Introduction</td>
<td>1</td>
<td>Syllabus information, Team formation, Grading</td>
<td>Chapters 1-3;</td>
</tr>
<tr>
<td></td>
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<td>policy negotiations</td>
<td>NS-I Chapters 1,2, 8.3</td>
</tr>
<tr>
<td>Module 1: Introduction to Conduction</td>
<td>2</td>
<td>Readiness Assessment Test; Concept Problems</td>
<td>Chapters 1-3;</td>
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<td></td>
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<td>NS-I Chapters 1,2, 8.3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Complex Problems</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>Complex Problems; Exam 1</td>
<td></td>
</tr>
<tr>
<td>Module 2: Advanced Conduction</td>
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<td>Readiness Assessment Test; Concept Problems</td>
<td>Chapters 4 &amp; 5;</td>
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<td>NS-I Chapter 8.4-8.7</td>
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<td>6</td>
<td>Complex Problems; Exam 2</td>
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<tr>
<td>Module 3: Introduction to Convection</td>
<td>7</td>
<td>Readiness Assessment Test; Concept Problems</td>
<td>Chapters 6 &amp; 7</td>
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<td>8</td>
<td>Complex Problems; Exam 3</td>
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<tr>
<td>Module 4: Convection and Heat Exchangers</td>
<td>9</td>
<td>Readiness Assessment Test; Concept Problems</td>
<td>Chapters 8 &amp; 11</td>
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<td>10</td>
<td>Complex Problems</td>
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<td>Complex Problems; Exam 4</td>
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<td>Module 5: Advanced Convection</td>
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<td>Readiness Assessment Test; Concept Problems</td>
<td>Chapters 9 &amp; 10</td>
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<td>Complex Problems; Exam 5</td>
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<td>Module 6: Radiation</td>
<td>14</td>
<td>Readiness Assessment Test; Concept Problems</td>
<td>Chapters 12 &amp; 13</td>
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<td></td>
<td>15</td>
<td>Complex Problems; Exam 6</td>
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</table>
NUC ENG 5257: Introduction to Nuclear Thermal Hydraulics

TWO-PHASE FLOW IN ENERGY APPLICATIONS

INTRODUCTION TO NUCLEAR THERMAL HYDRAULICS

NUC ENG 5257
T-Th 12:30 – 1:45
Fulton 227

INSTRUCTOR:
Dr. Joshua P. Schlegel
226 Fulton Hall
Office Hours: Wednesday 9:00-11:00, Tuesday/Thursday 9:00-11:00 (or by appointment)

TEL: 573.341.7703
EMAIL: schlegelj@mst.edu

TEXT BOOK:

COURSE DESCRIPTION:
An introductory course for students interested in the application of fluid flow and heat transfer to energy production. Students will learn the fundamentals of the scientific method in engineering and review fundamental principles of fluid mechanics and power cycle analysis. Modeling of single-phase flows and applications to energy systems will be discussed, as will fundamentals of heat transfer in nuclear fuels and reactor systems. The fundamental challenges of two phase flows and the field equations will be introduced with examples. Mixture properties and models, void fraction correlations, and pressure drop correlations for two-phase flows will be introduced, followed by two-fluid models for multiphase flows. Fundamentals of boiling phenomena and interfacial area transport will be discussed.

COURSE OBJECTIVES:
1. Understand and use the scientific method for engineering problems
   A. Describe the role of various kinds of experimental observations
   B. Describe the role of mathematical modeling and its fundamental principles
2. Derive and use mathematical models from first principles
   A. Derive the key balance equations from the general balance equation
   B. Use proper averaging techniques
   C. Identify and apply appropriate simplifying assumptions
   D. Identify key unknowns and required constitutive relations
   E. Simplify models using dimensional analysis
3. Apply control volume models to nuclear reactor scenarios
   A. Calculate Power Cycle Efficiency
   B. Evaluate Accident Scenarios
4. Apply fundamental concepts of single-phase fluid mechanics and heat transfer to power systems
   A. Apply simplifications for turbulence and RANS
   B. Solve fluid problems using Bernoulli’s Equation
   C. Calculate head loss and pressure drop with the Extended Bernoulli’s Equation
   D. Calculate conduction in fuel elements
   E. Calculate convection in laminar and turbulent flow
5. Describe the field equations for two phase flow and their physical significance
   A. Describe the void fraction and interfacial area concentration
   B. Write and describe the interfacial jump and interfacial boundary conditions
   C. Describe the significance Rayleigh-Taylor and Kelvin-Helmholtz Instability and model them using the field equations
6. Describe the various two-phase flow models
   A. Identify mixture properties
   B. Calculate flow behavior using slip and drift-flux models
   C. Describe the physical significance of the two-fluid model used in most modern calculations
   D. Identify the key constitutive relations and interfacial transfer laws necessary for the two-fluid model
   E. Compare and contrast the various approaches for modeling interfacial area concentration

7. Describe and use key models for boiling phenomena
   A. Sketch the boiling curve for pool boiling and describe its key features
   B. Calculate critical heat flux and minimum film boiling point for pool conditions

What will students get out of this class?
- Improved critical thinking abilities
- Ability to translate real-world problems into engineering models
- Deeper understanding of the role of the scientific method in engineering research
- Ability to develop engineering models in a rigorous and scientific fashion
- Deeper understanding of key challenges and research topics in nuclear thermal hydraulics
- Improved technical communication ability
- Excitement about nuclear thermal hydraulics

GRADING POLICY:
Final grades will be assigned as in Table 1. These grades will be a weighted average of exam and homework scores, with the weights given in Table 2 or Table 3, depending on the course you have enrolled in.

Table 1: Final Grade Assignments

<table>
<thead>
<tr>
<th>Performance</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent Performance in the Class</td>
<td>A</td>
</tr>
<tr>
<td>Good Performance in the Class</td>
<td>B</td>
</tr>
<tr>
<td>Acceptable Performance in the Class</td>
<td>C</td>
</tr>
<tr>
<td>Poor Performance in the Class</td>
<td>D</td>
</tr>
<tr>
<td>Failed to Meet the Minimum Class Requirement</td>
<td>F</td>
</tr>
</tbody>
</table>

* This is a guarantee. Any student who receives above an 85 will receive an A under all circumstances. However I reserve the right to curve the class (reducing the cutoff for an A to 75, for example) when appropriate.

Table 2: Final Grade Weighting, NE 5257

<table>
<thead>
<tr>
<th>Item</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exams (3)</td>
<td>50%</td>
</tr>
<tr>
<td>Homework</td>
<td>20%</td>
</tr>
<tr>
<td>Research Assessment - Rough Draft</td>
<td>15%</td>
</tr>
<tr>
<td>Research Assessment - Final Draft</td>
<td>15%</td>
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</tbody>
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Table 3: Final Grade Weighting, NE 4257

<table>
<thead>
<tr>
<th>Item</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exams (3)</td>
<td>60%</td>
</tr>
<tr>
<td>Homework</td>
<td>40%</td>
</tr>
</tbody>
</table>

HOMEWORK AND EXAMS:
Homework will be due in class one week from the date it is assigned. Due dates are listed in the syllabus. It will be turned in to the instructor at the beginning of the class period. Late homework will be accepted, with a penalty of 5% per day late (real day, not class day).
Homework grading:
- Each homework will be worth 100 points.
- 20 points will be awarded for formatting, listed below. As engineers, communicating our work is essential or it doesn’t do anyone any good.
- Each homework will consist of four problems worth 20 points each: one multi-part short answer problem on key concepts and definitions and three analysis problems.

Homework requirements (also useful for exams):
- Use engineering paper or plain white paper (NOT lined notebook paper). Use a separate sheet for each problem. Staple multiple pages. The instructor is not responsible for missing pages. (5 points)
- Include your name, class number, and assignment in the header of each page. Also include the page number of each page for assignments with multiple pages. (5 points)
- Write legibly and large enough to read clearly. Work that cannot be read/followed will not receive points.
- Work neatly. Follow the problem-solving method discussed in class. If necessary, include a neat sketch of the problem. Solve the problem in an organized, logical fashion. Illegible handwriting or sloppy work WILL result in lost points! (10 points)
- Show all your work to receive all the credit.
- Clearly indicate your answer. Make sure your answer includes appropriate units.

Homework tips:
- Be mindful of significant digits.
- Always double-check your units and conversions. You can often work out how to solve a problem just by looking at the units, and mistakes in your work can often be found by checking the units of your solution against the expected units.
- Make sure to read the problem carefully, and answer the question correctly.

Exams:
- Exams will be given in class.
- One page (front and back) of notes will be allowed for each student on each exam. I don’t expect memorization; I expect that you will understand how to use the equations.
- Bring a calculator for the exams in addition to your notes.

RESEARCH ASSESSMENT PAPER:
Graduate students will be expected to prepare a research assessment paper on a topic within two-phase flows. This project will count for 30% of the final grade. Students will be required to
1) Select an appropriate research paper from the literature. The paper should relate to thermal hydraulics, and if possible have applications to the student’s graduate research.
2) Use the knowledge and analytical techniques gained during this course to evaluate the research presented in the paper.
3) Prepare a short report detailing their analysis of the paper.
   a. The rough draft of the report will be due about one month prior to the end of the semester. The instructor will provide comments and feedback prior to submission of the final draft.
   b. The final draft will be due at the end of the last week of the semester.

The report should contain the following sections:
1) Abstract
2) Introduction describing the research problem, the importance of the research problem, and why this particular paper was chosen.
3) Summary of the selected research paper
4) Analysis of the research methodologies in the selected paper, with emphasis on evaluating methods and suggesting improvements.
5) Analysis of the results and conclusions in the paper.
6) Conclusions regarding the methods and results of the paper
7) References, to include proper citations of all publications referenced in the report.

A sample format and grading rubric will be posted on Blackboard for students to access. Formatting requirements include:
- Font: Times New Roman, 14 point, 1.5 spacing (CTRL+5 in MS Word)
One-inch margins
Number each page
Primary section headings should be bolded. Secondary headings should be italicized. Tertiary headings should be formatted normally. All headings should be numbered.
Any figures/images should be of sufficient quality that they are clearly visible
Please see the rubric for additional requirements

ATTENDANCE AND PARTICIPATION:
Participation in class, and therefore attendance, is important to developing the skills necessary to succeed in any course. Not all of the important material will be included in the presentation slides; a good deal will be presented and discussed only in class. That said, attendance will not be taken in this class. You are responsible for your own attendance. If you must miss class for some reason (other coursework, family emergency, sick, etc) please inform the instructor prior to, or as soon as possible after, the missed class to make arrangements related to missed material.

It is expected that you will be respectful during class periods. Please keep outside distractions to a minimum. Do not engage in side conversations with other students. Electronics in the classroom are encouraged, but don’t let them become a distraction. Keep cell phones and tablets on silent.

BLACKBOARD:
Lecture presentations, homework assignments, supplemental material, and grades will be posted on blackboard in a timely fashion. Please note that the lectures do not contain all of the necessary information, so these files are not a substitute for attending lectures. Follow your progress on blackboard, and speak to the instructor if you believe a grade was reported incorrectly or if you are concerned about your progress. Make sure to bring in your graded work if you believe a grade was reported incorrectly.

ACADEMIC DISHONESTY:
A student enrolling in the University assumes an obligation to behave in a manner compatible with the University's function as an educational institution. Page 33 of the Student Academic Regulations handbook describes the student standard of conduct relative to the System's Collected Rules and Regulations section 200.010, and offers descriptions of academic dishonesty including cheating, plagiarism or sabotage. Please review the Student Academic Regulations in the address above. Plagiarism, cheating, and other forms of academic dishonesty will result in a failing grade for the assignment and possibly the course.

http://registrar.mst.edu.academicregs/index.html

The student council honor code can be found at http://stuco.mst.edu/about/honor.shtml. The honor code highlights two important topics: honesty and respect.

Honesty is the effort to be truthful. When your instructor asks for your own work, make sure you turn in your own work. Trying to pass off the work of another student, past or present, as your own work is dishonest. If you borrow ideas from someone else, make sure you give credit where credit is due: cite the work properly.

Respect yourself enough to believe that you can do the work on your own, and enough to want to be a better person intellectually and ethically. Fundamentally, cheating shows a profound lack of self-respect. Respect your fellow students enough to make sure that the assessments are a fair evaluation of everyone’s own ability. Remember that if one person is dishonest it can affect the entire class. Respect other students study habits. Respect your instructors. Always be professional in your interactions with other students, members of the faculty, and University staff.

DISABILITY SUPPORT SERVICES:
Any student inquiring about academic accommodations because of a disability should contact Disability Support Services so that appropriate and reasonable accommodative services can be determined and recommended. Disability Support Services is located in 204 Norwood Hall. Their phone number is 341-4211 and their email is dss@mst.edu.
CONCERNS AND COMPLAINTS:
If there are concerns of complaints please talk to me and I will try to respond your worries and concerns. If you feel you cannot talk with me, please feel free to talk to the Department Chair, Dr. Hyoung K. Lee (leehk@mst.edu).

TITLE IX
Missouri University of Science and Technology is committed to the safety and well-being of all members of its community. US Federal Law Title IX states that no member of the university community shall, on the basis of sex, be excluded from participation in, or be denied benefits of, or be subjected to discrimination under any education program or activity. Furthermore, in accordance with Title IX guidelines from the US Office of Civil Rights, Missouri S&T requires that all faculty and staff members report, to the Missouri S&T Title IX Coordinator, any notice of sexual harassment, abuse, and/or violence (including personal relational abuse, relational/domestic violence, and stalking) disclosed through communication including but not limited to direct conversation, email, social media, classroom papers and homework exercises.

Missouri S&T’s Title IX Coordinator is Vice Chancellor Shenethia Manuel. Contact her directly (manuels@mst.edu; (573) 341-4920; 113 Centennial Hall) to report Title IX violations. To learn more about Title IX resources and reporting options (confidential and non-confidential) available to Missouri S&T students, staff, and faculty, please visit http://titleix.mst.edu.
### TENTATIVE SCHEDULE (SUBJECT TO CHANGE):

<table>
<thead>
<tr>
<th>Week</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Lecture 01 - Course Introduction</td>
</tr>
<tr>
<td>1b</td>
<td>Lecture 02 - Fundamentals of Nuclear Thermal Hydraulics</td>
</tr>
<tr>
<td>2a</td>
<td>Lecture 02 - Fundamentals of Nuclear Thermal Hydraulics</td>
</tr>
<tr>
<td>2b</td>
<td>Lecture 03 - Integral Analysis</td>
</tr>
<tr>
<td>3a</td>
<td>Lecture 03 - Integral Analysis</td>
</tr>
<tr>
<td>3b</td>
<td>Lecture 03 - Integral Analysis</td>
</tr>
<tr>
<td>4a</td>
<td>Lecture 04 - Thermodynamic Analysis of Nuclear Power Plants</td>
</tr>
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<td>4b</td>
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<td>5a</td>
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<td>Lecture 04 - Thermodynamic Analysis of Nuclear Power Plants</td>
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<tr>
<td>6a</td>
<td>Lecture 05 - Differential Analysis</td>
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<td>6b</td>
<td>Exam 1 - L01-L04</td>
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<td>7a</td>
<td>Lecture 05 - Differential Analysis</td>
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<td>7b</td>
<td>Lecture 06 - Elementary Fluid Mechanics</td>
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<td>8a</td>
<td>Lecture 06 - Elementary Fluid Mechanics</td>
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<td>8b</td>
<td>Lecture 06 - Elementary Fluid Mechanics</td>
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<td>Lecture 07 - Elementary Heat Transfer</td>
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<td>9b</td>
<td>Lecture 07 - Elementary Heat Transfer</td>
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<td>10a</td>
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<td>10b</td>
<td>Lecture 08 - Introduction to Two Phase Flows</td>
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<td>11a</td>
<td>Lecture 09 - Basic Two Phase Flow Problems</td>
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<td>11b</td>
<td>Exam 2 - L05-L07</td>
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<td>12a</td>
<td>Lecture 09 - Basic Two Phase Flow Problems</td>
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<td>Lecture 10 - Mixture Models</td>
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<td>13c</td>
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<tr>
<td>14a</td>
<td>Lecture 11 - Boiling and Condensation</td>
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<tr>
<td>14b</td>
<td>Lecture 11 - Boiling and Condensation</td>
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<td>15b</td>
<td></td>
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<td>16a</td>
<td></td>
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<tr>
<td>16b</td>
<td>Exam 3 - L08-L11</td>
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</tbody>
</table>
ADVANCED TOPICS IN NUCLEAR THERMAL HYDRAULICS
NUC ENG 6099
Monday, 1:00-2:30 and by appointment
Fulton 211

INSTRUCTOR:
Dr. Joshua P. Schlegel
226 Fulton Hall
Office Hours: by appointment

Tel: 573.341.7703
Email: schlegelj@mst.edu

COURSE DESCRIPTION:
Student-led discussions of advanced research topics in nuclear thermal hydraulics, focusing on current research activities for each student. Topics will include experimental techniques, data analysis, analytical modeling, computational modeling, paper writing, thesis/dissertation writing, research presentations, and analysis of the work of others.

COURSE OBJECTIVES:
1. Improve awareness of current research concerns in nuclear thermal hydraulics
2. Expand knowledge of experimental and data analysis techniques
3. Expand knowledge of analytical and computational modeling techniques
4. Improve technical communication skills
   a. Delivering written content
   b. Delivering oral content
   c. Analyzing and responding to content

What will students get out of this class?
- Improved critical thinking abilities
- Ability to translate real-world problems into engineering models
- Deeper understanding of key challenges and research topics in nuclear thermal hydraulics
- Expanded knowledge of experimental techniques
- Expanded knowledge of modeling techniques
- Improved technical communication ability
- Excitement about nuclear thermal hydraulics

GRADING POLICY:
Final grades will be based on
1. An oral presentation
2. Participation
3. End-of-Semester Written Summary
4. Instructor evaluation of research activities

Grades will be pass/fail (satisfactory/unsatisfactory)

COURSE STRUCTURE:
The overall instructor evaluation, evaluation of the oral presentation, and evaluation of the written summary will be completed on a single form. This form is available in the Nuclear Engineering Graduate Students group on Canvas.
Oral Presentation
The oral presentation will be given to the other students during one of the bi-weekly meetings. It should last 35-40 minutes (leaving about 15-20 minutes for questions). It should cover the following major topics:

1. **Problem Definition:** Clearly define the research problem you are trying to solve and explain why that problem is important and its potential impact in the area of study; clearly state the specific objectives of your work.
2. **Literature and Previous Work:** Describe how your work fits into the previous work done in the field; emphasize what is new/novel about your work and what gaps in the existing knowledge your work will help fill; demonstrate sound knowledge of the existing literature in the research area.
3. **Solution Plan:** Describe a sound plan for applying state-of-the-art techniques to solve your problem; show a thorough understanding of how to use those techniques effectively.
4. **Previous Results:** Describe the existing or previous results of your work; this may include experiment design, previously collected data, previously developed models, simulations performed, etc.; interpret those results.
5. **Expected Results:** Discuss the results you expect to see and how you plan to analyze and interpret those results.
6. **Critical Thinking:** Demonstrate capacity for independent research, preparedness in core disciplines, and ability to complete research.
7. **Broader Impact:** Demonstrate awareness of the broader implications of the proposed research, including social, economic, technical, and ethical aspects.

The major focus of this presentation should be on (a) what you have accomplished in the previous 6 months, and (b) what you plan to accomplish in the next six months. At the beginning of a research project/program, this may be items 2, and 3. Later in a project/program, this will be in sections 4 and 5.

Written Summary
The written summary should be no more than one page. It should include two sections. The first section should be about 2/3 of the total and should detail your research activities over the last 6 months, focused on accomplishments rather than activities (results obtained, designs completed, papers submitted/accepted, and so on). The second section should be about 1/3 of the total and should describe your planned activities over the next six months (again, focusing on specific milestones – complete the design by a certain date, submit a paper by a certain date, finish construction by a certain date, etc.). Discussing this summary with the instructor prior to submission is encouraged as a planning tool for your research and degree progress.

Participation
Attendance and participation at research meetings is mandatory, although exceptions will be made for extenuating circumstances. Participation will be evaluated based on the questions students ask following each presentation. During or after each presentation all students not presenting are **required** to ask at least one question of the speaker. Questions may be on topics specific to the research project, or may be more fundamental questions about the physical principles and ideas the research is based on. This encourages analysis of the material during the presentation and gives the speaker a chance to practice answering questions without a script.

Participation will also be evaluated on participation in group discussions. **Students are encouraged to discuss difficulties in their research with other students during research meetings in addition to discussing them with their advisor.** Then the student who is having difficulty and the other students can engage in a thoughtful discussion with the advisor, rather than having the advisor simply give them dictated instructions. This kind of peer-to-peer interaction helps teach everyone in the research group about the various projects and can lead to new, interesting ideas and directions for research projects.

Instructor Evaluation
At the end of the term the instructor will evaluate all participants based on the quality of their presentation, the work and plan laid out in their written summary, and their participation in group discussions. The instructor will also evaluate the participant’s performance as a researcher over the previous six months. The evaluation form is available on the Canvas page.
Following the evaluation, students are encouraged to meet with the instructor to discuss their professional
development goals. The instructor may be able to recommend some specific activities that will be helpful (CV
workshops, proposal writing seminars, teaching workshops, course development activities, conferences, etc.).

**CANVAS:**
Course information, evaluation rubrics, supplemental materials, and so on will be posted in Canvas in the Nuclear
Engineering Graduate Students group. This group is permanent, and will be updated each semester with the
appropriate information.

The Canvas group will act as a central repository for announcements, research reports and key files, journal and
conference publications, resumes and CVs, and other documents. Each research project has a group associated with it,
which includes all of the students currently participating in that research projects. Files are stored in a central
repository within the Canvas group. Student teams are encouraged to store or exchange files, create web pages for
their projects, and so on. At a minimum each project folder in the file structure will contain the research proposal, any
progress reports required by the research sponsor, and (once it is completed) the final report for the project.

**ACADEMIC DISHONESTY:**
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function as an educational institution. Page 33 of the Student Academic Regulations handbook describes the student
standard of conduct relative to the System's Collected Rules and Regulations section 200.010, and offers descriptions
of academic dishonesty including cheating, plagiarism or sabotage (http://registrar.mst.edu/media/administrative/Registrar/documents/academicregulations/academic_regulations_2014-2016.pdf). Please review the Student Academic Regulations in the address above. Plagiarism, cheating, and
other forms of academic dishonesty will result in a failing grade for the assignment and possibly the course.

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two important topics: honesty and respect.

**DISABILITY SUPPORT SERVICES:**
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Services so that appropriate and reasonable accommodative services can be determined and recommended. Disability
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http://dss.mst.edu

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you cannot talk with me, please feel free to talk to the Department Chair, Dr. Hyoung K. Lee (leehk@mst.edu).

**TITLE IX:**
Missouri University of Science and Technology is committed to the safety and well-being of all members of its
community. US Federal Law Title IX states that no member of the university community shall, on the basis of sex, be
excluded from participation in, or be denied benefits of, or be subjected to discrimination under any education
program or activity. Furthermore, in accordance with Title IX guidelines from the US Office of Civil Rights, Missouri
S&T requires that all faculty and staff members report to the Missouri S&T Title IX Coordinator, any notice of sexual
harassment, abuse, and/or violence (including personal relational abuse, relational/domestic violence, and stalking)
disclosed through communication including but not limited to direct conversation, email, social media, classroom
papers and homework exercises.

Missouri S&T’s Title IX Coordinator is Vice Chancellor Shenethia Manuel. Contact her directly (manuels@mst.edu;
(573) 341-4920; 113 Centennial Hall) to report Title IX violations. To learn more about Title IX resources and
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Advanced Nuclear Thermal Hydraulics

NUC ENG 6207
M-W-F 9:00-9:50 AM
ROOM

INSTRUCTOR:
Dr. Joshua P. Schlegel
226 Fulton Hall, Tel: 573.341.7703, email: schlegelj@mst.edu
Office Hours: M/W/F 10:00 – 11:30 AM

TEXT BOOK:

COURSE DESCRIPTION:
Integrated treatment of thermodynamics and advanced mass, momentum and energy transport in solids and fluids; velocity and temperature distributions in laminar and turbulent flow; flow and thermal analysis with applications to nuclear engineering systems.

COURSE OBJECTIVES:
At the end of this course, students should be able to:

- Acquire a fundamental knowledge of the thermal-hydraulic problems of interest in nuclear systems
- Identify, describe and solve problems relating to various types of power cycles.
- Appropriately use engineering approximations to calculate flow rates and pressure drops in single-phase and two-phase fluid systems
- Appropriately use engineering approximations to calculate heat transfer by conduction and convection.
- Know and use terminology specific to thermal-hydraulic problem-solving methods used in the nuclear industry.
- Know and use important dimensionless parameters in nuclear thermal-hydraulics.

GRADING POLICY:
Final grades will be assigned as in Table 1. These grades will be a weighted average of exam and homework scores, with the weights given in Table 2.

Table 1: Final Grade Assignments

<table>
<thead>
<tr>
<th>Grade Description</th>
<th>Score Range</th>
<th>Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent Performance in the Class</td>
<td>100 – 85</td>
<td>A</td>
</tr>
<tr>
<td>Good Performance in the Class</td>
<td>84 – 75</td>
<td>B</td>
</tr>
<tr>
<td>Acceptable Performance in the Class</td>
<td>74 – 65</td>
<td>C</td>
</tr>
<tr>
<td>Poor Performance in the Class</td>
<td>64 – 50</td>
<td>D</td>
</tr>
<tr>
<td>Failed to Meet the Minimum Class Requirement</td>
<td>49 – 0</td>
<td>F</td>
</tr>
</tbody>
</table>
Table 2: Final Grade Weighting

<table>
<thead>
<tr>
<th>Item</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exams (3)</td>
<td>75%</td>
</tr>
<tr>
<td>Homework (7)</td>
<td>25%</td>
</tr>
</tbody>
</table>

**HOMEWORK:**
Homework will be due in class one week from the date it is assigned. It will be turned in to the instructor at the beginning of the class period. Late homework will be accepted, with a penalty of 20% per day late. All homework assignments must be turned in by the end of the semester, even if more than 5 days late. Failure to turn in all homework will result in an incomplete grade.

Homework requirements (also useful for exams):
- Use engineering paper or plain white paper. Use a separate sheet for each problem.
- Staple multiple pages. The instructor is not responsible for missing pages.
- Include your name, class number, and assignment in the header of each page. Also include the page number for assignments with multiple pages.
- **Write legibly** and large enough to read clearly. Work that cannot be read/followed will not receive points.
- **Work neatly.** Clearly specify the given information, what you are solving for, any engineering assumptions that are required, and any important equations that will be used. If necessary, include a neat sketch of the problem. Solve the problem in an organized, logical fashion.
- **Show** all your work to receive all the credit.
- Clearly indicate your answer. Make sure your answer includes appropriate units.

Homework tips:
- Be mindful of significant digits.
- Always double-check your units and conversions. You can often work out how to solve a problem just by looking at the units, and mistakes in your work can often be found by checking the units of your solution against the expected units.
- Make sure to read the problem carefully, and answer the question correctly.

Homework grading:
- Each homework will be worth 100 points.
- 20 points will be awarded for formatting, listed above. As engineers, communicating our work is essential or it doesn’t do anyone any good.
- Problems will be assigned a value based on their complexity (the value of each problem will be given with the assignment).
ATTENDANCE AND PARTICIPATION:
Participation in class, and therefore attendance, is important to developing the skills necessary to succeed in any course. Not all of the important material will be included in the presentation slides; a good deal will be presented and discussed only in class. That said, attendance will not be taken in this class. You are responsible for your own attendance.

If you must miss class for some reason (other coursework, family emergency, sick, etc) please inform the instructor prior to, or as soon as possible after, the missed class to make arrangements related to missed material.

It is expected that you will be respectful during class periods. Please keep outside distractions to a minimum. Do not engage in side conversations with other students. Electronics in the classroom are encouraged, but don’t let them become a distraction. Keep cell phones and tablets on silent.

BLACKBOARD:
Lecture presentations, homework assignments, supplemental material, and grades will be posted on blackboard in a timely fashion. Please note that the lectures do not contain all of the necessary information, so these files are not a substitute for attending lectures. Follow your progress on blackboard, and speak to the instructor if you believe a grade was reported incorrectly or if you are concerned about your progress. Make sure to bring in your graded work if you believe a grade was reported incorrectly.

ACADEMIC DISHONESTY:
A student enrolling in the University assumes an obligation to behave in a manner compatible with the University's function as an educational institution. Page 33 of the Student Academic Regulations handbook describes the student standard of conduct relative to the System's Collected Rules and Regulations section 200.010, and offers descriptions of academic dishonesty including cheating, plagiarism or sabotage. Please review the Student Academic Regulations in the address above. Plagiarism, cheating, and other forms of academic dishonesty will result in a failing grade for the assignment and possibly the course.

http://registrar.mst.edu/academicregs/index.html

Disability Support Services:
Any student inquiring about academic accommodations because of a disability should contact Disability Support Services so that appropriate and reasonable accommodative services can be determined and recommended. Disability Support Services is located in 204 Norwood Hall. Their phone number is 341-4211 and their email is dss@mst.edu.

http://dss.mst.edu

Concerns and Complaints:
If there are concerns of complaints please talk to me and I will try to respond your worries and concerns. If you feel you cannot talk with me, please feel free to talk to the Department Chair, Dr. Hyoung K. Lee (leehk@mst.edu).
Title IX
Missouri University of Science and Technology is committed to the safety and well-being of all members of its community. US Federal Law Title IX states that no member of the university community shall, on the basis of sex, be excluded from participation in, or be denied benefits of, or be subjected to discrimination under any education program or activity. Furthermore, in accordance with Title IX guidelines from the US Office of Civil Rights, Missouri S&T requires that all faculty and staff members report, to the Missouri S&T Title IX Coordinator, any notice of sexual harassment, abuse, and/or violence (including personal relational abuse, relational/domestic violence, and stalking) disclosed through communication including but not limited to direct conversation, email, social media, classroom papers and homework exercises.

Missouri S&T’s Title IX Coordinator is Vice Chancellor Shenethia Manuel. Contact her directly (manuels@mst.edu; (573) 341-4920; 113 Centennial Hall) to report Title IX violations. To learn more about Title IX resources and reporting options (confidential and non-confidential) available to Missouri S&T students, staff, and faculty, please visit http://titleix.mst.edu.
Tentative Schedule (Subject to Change):

<table>
<thead>
<tr>
<th>Date</th>
<th>Planned Contents</th>
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<tr>
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<td>Introduction, Course Objectives</td>
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<tr>
<td>August 27</td>
<td>Review of Thermodynamics</td>
<td>NS, Ch. 6</td>
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<td>First Law of Thermodynamics</td>
<td>NS, Ch. 6</td>
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<td>Second Law of Thermodynamics</td>
<td>NS, Ch. 6</td>
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<td>September 5</td>
<td>Thermodynamics of Nuclear Energy Conversion</td>
<td>NS, Ch. 3</td>
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<tr>
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<td>NS, Ch. 6</td>
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<td>September 10</td>
<td>Carnot Cycle and Thermodynamic Efficiency</td>
<td>NS, Ch. 6</td>
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<td>Brayton Cycle</td>
<td>NS, Ch. 6</td>
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<td>September 15</td>
<td>Rankine Cycle</td>
<td>NS, Ch. 6</td>
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<tr>
<td>September 17</td>
<td>Reactor Systems and Components</td>
<td>NS, Ch. 1</td>
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<td>Exam 1 Review Session</td>
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<td>Transport Equations for Single-Phase Flow</td>
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<td>NS, Ch. 9</td>
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<td>EXAM #1: THERMODYNAMICS</td>
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<td>Single-Phase Fluid Mechanics</td>
<td>NS, Ch. 9</td>
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<td>Critical Flow</td>
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<td><strong>December 12</strong></td>
<td>EXAM #3: HEAT TRANSFER</td>
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APPENDIX E – SELECTED STUDENT EVALUATION COMMENTS

Fall 2014:

**NUC ENG 6207:**
Excellent knowledge of material and availability outside of class. Lecture content did not always correspond with homework assignments. Instructor spent a lot of time on detailed derivations of various equations and correlations and not so much time on practical application.

Excellent teaching capabilities. Very hard working and cares about his students. More importantly stick to the rules which is of great commendation.

The instructor is very concerned with our learning progress. Although this is the first time for the instructor to teach this course, the instructor tried his best to teach well. Like each time after the test, the instructor would ask for our course evaluations back.

Before lecturing on a topic he should build some foundation on it like what is it and how it is relevant etc.

Experience needed for the course. Teaching skills play important role since this is an advanced version of three courses combined.

Course was well structured and aimed to give as much knowledge as possible. There was no hand on realization on the subject matter.

It is an advanced course such that assuming student to have background knowledge. There should be more examples of problem solving

Set prerequisites for the course - thermodynamics, fluid mechanics and heat transfer, spend less time on basics and explain the advanced concepts in depth while relating to those basics in between, spend a bit more time on fluid mechanics, transport equations and less on the initial thermodynamics. Also, u could consider distributing the notes or making PPT of equations and explaining directly from them instead of writing it on the board- saves a lot of time.

I do not know if it is possible to separate this course into two parts and then teach this course during two semesters. But I think that would be better for students to learn.

Spring 2015:

**NUC ENG 4257/5257:**
The professor was well organized and effectively presented course material necessary for a good understanding of two phase flow.

Strengths: Concerned about the students learning and understanding of the material. Weaknesses: Inexperienced in teaching practices, and different learning styles. Information was often scattered and wasn't clear to the students what the connections were.

Strength: Definitely knows the course material and comes prepared with slides/notes ready to go for the class Weakness: The fact that he knows the material so well causes him to skip explanations of intermediate steps that someone who hasn't taken fluid mechanics in a year may not understand fully; Sometimes goes through the notes and material too quickly in class

Strengths- explaining and reviewing material in multiple ways to help students understand the
Instructor is very concerned about students understanding and enjoys the topic. Once the formulas start getting complex like in 2-fluid or mixture models, the explanation of the terms in continuity, momentum, energy equations became quicker and harder to keep up with. I only took half of a page of notes when I should have taken 3 because he talked so fast. He is generally available during office hours and willing to cover anything a student may have missed.

Allow time for professor to get better at teaching. And have the professor be willing and excited to learn how to teach, as he currently is. Less test, more projects! It is more interesting to use models in real life applications than memorizing a bunch of equations for a test. At some point during the semester, I found myself cramping thousand of equations and mathematical symbols.

**Fall 2015:**

**NUC ENG 4496:**
The instructor did well to politely point out issues with group designs. Plus the fact that the instructor was willing to re-evaluate his grading policy and correct any errors he made on his behalf. Also kept the course fairly light and fun given the magnitude of the course. It also would have been nice to allow more time for students to come up with design ideas. Though class time is valuable it would be nice to send something out before classes started in order to give students time to maul over ideas.

I would make sure to talk to all the groups each class period since time is very important during this class. It seemed like some groups were excluded during some of the classes even though the professor talked about flaws in group designs it would have been nice to hear some of the positives of the design.

Instead of just explaining why one method won’t work try to come up with a way that method would work to see if maybe there was a miscommunication so that things are not contradicted as much.

**NUC ENG 3221:**
The most kind and caring professor I have ever had. He truly wants all of his students to succeed. The instructor is obviously intelligent, with great understanding of the material. However, I think sometimes he relies on notes too much and gets in a routine of simply rolling through what needs to be learned. He does however make up for this with his concern for each person's understanding of the material through the use of office hours and answering any and all questions.

Dr. Schlegel really does care about his students and wants them to learn and succeed; however, there was a block in communication that prevented much of the material comprehension.

Invests the time to cover examples in detail. Works clearly and easy to follow. Good communicator.

Dr. Schlegel was willing to improve on his teaching skills and in the way he taught constantly,
which was one of his biggest strengths. He was not super great at describing things in class in a way that was both interesting and engaging. If you asked for help, or attended LEAD, he was good at describing things outside of class.

As much as the students may not like it, you should force participation in class to break the monotony.

I would suggest more practice problems and more lessons on the conceptual ideas of each topic rather than just textbook recitation.

Very tough, made me push hard to earn a grade

This course is difficult, requiring a lot of focus and studying. However, the educational payoff through understanding is immense.

Lectures were too fast. Examples were great but at times hard to follow. During examples skipping steps made it hard to follow.

Understand that it was your first semester teaching, and that is more difficult than students will give you credit for. I understand your mindset with creating the tests where there is a larger range of the distribution, but I don't think it's the best method for learning the material for "real world" situations. The test problems (and some homework problems) are so complex that my understanding of the principles of fluids becomes jumbled, but that's partially because I didn't devote as much time to the class as I could have to fully understand the course. Basically, I would recommend to make sure that you teach at a level where the basic principles are solidified for everyone before complex problems are addressed.

Go slower through the lecture material. Keep doing examples. they were great!

It's a great class to prepare us for real world problems but sometimes overwhelms a person never seeing the content before.

This course is difficult, requiring a lot of focus and studying. However, the educational payoff through understanding is immense.

I felt that the course held a LOT of very important and vital information.

Spring 2016:

NUC ENG 3223:

The instructor really cares about how the students understand the material. He works hard to make sure that there is help available to students if they are not understanding the concepts and is also understanding when students are in situations that make turning in homework on time a challenge. One of the weaknesses, though, is that the content taught in the class is very low level compared to the knowledge required in the homework.

The instructor is very passionate about the material and knows it very well. I sometimes had trouble completing the examples in class as quickly as the instructor.

Posting practice problems on blackboard was great! I used them a lot when studying and working on homework problems.
Since last semester, Dr. Schlegel has improved his teaching methods significantly. He's trying to figure out effective ways to teach, and he is clearly making progress. He constantly asks for feedback from his students throughout the semester, and when it's provided, he implements a correction to his methods promptly. He seems to genuinely care that we understand the material. He's easy to arrange an appointment with to get help or go over mistakes. Also, he hosts LEAD sessions once a week to assist students with filling gaps in their knowledge and with homework. My only complaint would be the length of the exams. I consider myself a quick worker, and I was barely finishing (or barely not finishing) the exams. I heard from many other students that they didn't get close to finishing each exam.

Clear communication. Works out examples and highlights most important material. Provides information on theory, applications, correlations, and different numerical/empirical/analytical solutions.

Very knowledgeable regarding material, but relies too heavily on powerpoints

Very well prepared Very strong scientifically. communicates with student all the time

I think that you expected us to pick up concepts that are totally new to us, that are fairly complex in a very short amount of time. I think that you sort of "shot gunned" the class. You threw a lot of information at us quickly, and not a lot of it stuck to be honest.

Dr. Schlegel really knows what he is talking about. It is clear that he is able to understand and communicate many facts and pieces of information over a broad range of topics. I think that his good knowledge of the material can really aid in the explanation of certain topics. I do, however, think that often times he tries to explain things in a text book manner when students could use a simplified version, or just the essentials for many topics.

The instructor could spend more time focusing on example problems and less time focusing on things that could be easily learned from the textbook.

Spend more time explaining concepts than going over multiple equations.

I really believe that there is a little too much information in the powerpoints used in class. I think students benefit with a concise explanation of the reason of a problem, then the physics/math of a problem, then a summary of the ways to solve the problem. The book does alot of behind the scenes explanations so it isn't necessary to include all of this during class.

I liked the group involvement of solving problems. As long as everyone in the group participates, I think this would be very effective.

A forgiveness matrix i.e. a way to replace a test grade, extra credit, or the ability to re-do some homework or replace a homework grade. In your fluids class we did a project. I actually enjoyed this and this helped me realize how fluid mechanics was used in industry and this was a good way to help our grades as well. I would've enjoyed a small project in heat transfer so that we could see better how it applies and get some hands-on experience with it.
Introduce the concepts, show them with in depth examples. I think if you are relying too much on power point, it causes you to go too fast. Sit in on other professors. In my opinion, Dr. Mueller is the best in the department. He teaches slowly and in depth, and he doesn't even use you power point. I know that makes teaching more difficult, but it forces you to slow down and emphasis the most important info.

Make the course more related to nuclear material, rather than being so broad. It will reduce the amount of material that needs to be taught and allow for far more effective teaching.

**Fall 2016:**

*NUC ENG 3221:*

*NUC ENG 5257:***
**APPENDIX F – ANNUAL EVALUATION SUMMARIES**

**2015 Annual Review Summary**

**Confidential Report of Annual Performance Review**

**MNE Department Chair with Faculty Member (Calendar Year 2015)**

As part of the Faculty Activities Report Program, each department chair must annually, in the spring, prior to the May Commencement, discuss individually with faculty his/her assessment of their contributions. It is required that the department chair specifically comment on each of the following: 1) What were the duties this faculty member was expected to fulfill? 2) What has been performed well? 3) What needs improvement? 4) What objectives are agreed upon for the coming year? 5) The chair’s summary of the faculty member’s progress toward tenure and/or promotion during the past year when applicable. In addition, if not already covered above, the chair will summarize the primary contributions of the faculty member to the department, college, and/or university during the past year.

Faculty Member’s Name:  
Dr. Joshua Schlegel

Department:  
Mining and Nuclear Engineering

<table>
<thead>
<tr>
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**Chair’s Comments:**

**Overall**

Dr. Schlegel is a busy and effective young faculty member who is off to an excellent start, particularly in his publications and number of grants. Due to lab setup delays, his expenditures are lower than expected (but still reasonable). He has been very busy teaching (teaching too many new classes), but he should settle in to a two class per semester schedule of classes which he’s taught before. He is a promising young faculty member who is very sharp technically, is a productive scholar, is becoming an excellent teacher, and who will be a leader in the future.

**Post–Tenure Assessment:**  
Teaching (S)  
Research (S)  
Service (S)  
Overall (S)  
(U = Unsatisfactory; S = Satisfactory)

**Chair’s Signature:**  
Ralph E. Flori  
Date:  
March 29, 2016