| | |
|---|---|
| **From:** | Smith, Randy |
| **To:** | Siston, Robert; Metzler, Sandra; Cao, Raymond; Khafizov, Marat |
| **Cc:** | Sutherland, Sue; Herrmann, Samantha; Smith, Randy; Reed, Katie; Duffy, Lisa; Hunt, Ryan; Matyas, Cory; Tomasko, David; Howard, Ayanna; Kanzeg, Benjamin; Walsh, Tom; Jones, Norman; Talbot, Ann; Brown, Trevor; Griffiths, Rob; Hammond, Ivy; Gardner, Jared; Watson, Sara; Bellamkonda, Ravi V. |
| **Subject:** | Proposal to establish a Bachelor of Science in Nuclear Engineering |
| **Date:** | Thursday, April 23, 2026 9:17:07 AM |
| **Attachments:** | image001.png |

Robert, Marat, Sandra and Raymond,

The proposal from the Department of Mechanical and Aerospace Engineering to establish a Bachelor of Science in Nuclear Engineering was approved by the Council on Academic Affairs at its meeting on April 22, 2026. Thank you for attending the meeting to respond to questions/comments.

The proposal will now be sent to the University Senate with a request to be included for action at the Senate meeting on **September 17, 2026**. The Chair of the Council will present the proposal, but we will need you or a designee to attend to respond to detailed questions. Prior to that it will need discussion at the Faculty Council on **September 3, 2026,** and the Senate Steering Committee on **September 10, 2026**. I will provide you with details as I receive them.

If approved by the Senate, the proposal will be sent to the Board of Trustees for action at its meeting on **November 19, 2026.** If approved by the Board, my office will work with you on the approval process with the Ohio Department of Higher Education.

Once fully approved, the Office of the University Registrar will work you with you on any implementation issues.

The proposal alluded to a potential name change for the Department if this proposal were approved. That would require a separate proposal following the same process with approvals at the College, Council on Academic Affairs, University Senate, and Board of Trustees levels.

Please keep a copy of this message for your file on the proposal and I will do the same for the file in the Office of Academic Affairs.

If you have any questions please contact the Chair of the Council, Professor Sue Sutherland (.43), or me.

I wish you success with this important program development.

Randy

THE OHIO STATE UNIVERSITY

**W. Randy Smith, Ph.D.**
Vice Provost for Academic Programs
Office of Academic Affairs
University Square South, 15 E. 15th Avenue, Columbus, OH 43201
614-292-5881 Office
smith.70@osu.edu
**Assisted by:**
**Katie Reed**
Executive Assistant
(614) 292-5672

## Nuclear Engineering – Advising Structure (Q2)

Advising for the NE major will follow the same model used for Mechanical and Aerospace Engineering. Students will be assigned to a full time professional advisor as part of the undergraduate advising team for day-to-day support, including course planning, registration, degree progress, and policy questions. Program faculty will focus on discipline specific mentoring, such as selecting technical electives, connecting students with research and internships, and advising on preparation for graduate school. This shifts routine workload from the single faculty member who currently oversees the large NE minor. We will continue to have the NE minor, and we expect that the service workload for this faculty member will decrease as students shift into the major. No individual faculty member will be responsible for directing or carrying the advising load for the major.

## Nuclear Engineering – Assessment (Q3)

Assessment in the Nuclear Engineering program will follow the same collegewide model used in our other ABET accredited majors. Outcome attainment is evaluated through course embedded work with common rubrics in key courses, plus program level checkpoints such as capstone design evaluations. Multiple faculty score these artifacts within their courses, which means no single faculty member is responsible for "rating" student progress for the entire program. At the department level, this work is handled by our CQIC committees, and we will create a similar committee for the new Nuclear Engineering major that will mirror the existing committees for Aerospace and Mechanical Engineering. The College Outcomes Committee and our staff support departments with methods, templates, and data tools, and the undergraduate advising team tracks individual student progress toward degree requirements. Each year we analyze results, discuss them with faculty, and document specific actions, which can include revising assignments or rubrics, adjusting prerequisites or course sequencing, adding targeted student supports, and updating technical elective options. This approach meets ABET's requirements for evidence based assessment and continuous improvement and is the same process used across our accredited engineering programs.

## Nuclear Engineering — Admission to Major Clarification (Q4)

Nuclear Engineering (NE) would be administered as a limited-space program that uses the College of Engineering Admission to Major process. Students begin as pre-nuclear engineering, complete core eligibility courses, and then apply. Students must always verify the current cycle's criteria and dates on the official Admission to Major page.

**Eligibility Checklist for NE — complete by the end of your application term**

- Be enrolled in the Nuclear Engineering pre-major
- Have an Ohio State cumulative GPA of 2.0 or higher (good academic standing).

- Finish key college-core courses commonly used for limited-space majors: Calculus II, the Fundamentals of Engineering sequence (ENGR 1181 + 1182 or honors equivalents), and Physics I.

**How the Application Works**

1. Apply in the semester you finish the eligibility courses (two main cycles each year).
2. Use the single online application to rank up to three majors, verify coursework, and answer short essays.
3. Programs conduct a multi-factor, blind review considering your OSU GPA and essays. You receive one offer (if admitted) and must accept by the stated deadline.
4. You have up to two total attempts in the Admission to Major process.

**Is the College of Engineering moving to direct enrollment for all majors starting AU26?**

The College has communicated that it is moving toward a formal direct-enroll-to-major framework admissions cycle, and discussed this in the Sept. 17, 2025 Council on Academic Affairs meeting. Until new policy pages go live, the current published model still lists four pre-majors (AERO, BME, CSE/CIS, ME) that require an admission-to-major step.

**Will the current Limited Space Programs (LSP) vs Space Available Programs (SAP) model continue if/when COE moves to direct enrollment for all majors?**

At present, the LSP/SAP distinction remains in effect: Aerospace, Biomedical, Computer Science (CSE/CIS) and Mechanical are treated as limited-space programs that use the application-to-major process; all other listed programs are space-available (directly declare for eligible students). Nuclear Engineering will follow the same model as Mechanical/Aerospace. If the formal direct-enroll framework launches college-wide, the LSP/SAP labels could be revised; watch the official pages for an update.

**Under today's LSP/SAP model, how do NFYS, transfers, and current students enter majors?**

- NFYS to SAP: Newly admitted Columbus first-years who chose an SAP are directly enrolled in that major from pre-major without secondary application.
- Transfer to SAP: New transfer admits who meet COE transfer criteria can be placed directly into SAP majors.
- Current COE students: May major-change into an SAP by meeting the program's criteria and working with the destination advising unit.

- Current non-COE OSU students: May change into an SAP upon meeting the engineering change-of-program criteria.

**How does it work for LSPs (NE, AERO, BME, CSE/CIS, ME) under the current model?**

- NFYS who selected a specific LSP are placed into the associated pre-major and may need to later apply to that LSP via the Admission to Major process, ranking up to three choices (their LSP plus two alternates).
- Transfer admits who applied to an LSP and meet COE transfer criteria are placed into that LSP pre-major and then apply through the college process.
- First-year switching limits: admitted students may switch into one of the four pre-majors only until May 1; after that date, switches into these pre-majors are not permitted.
- Currently, only BME remains unable to admit all pre-majors and continues to use the Admission to Major Process. It is not anticipated that Nuclear Engineering would need to utilize the Admission to Major Process.

**For the proposed undergraduate Nuclear Engineering program will it be SAP or LSP?**

Nuclear Engineering plans to launch with matching processes to Mechanical and Aerospace Engineering.

However, we envision that we will take a modified approach to the LSP model for the first 2 years of the Nuclear Engineering program. While NYFS admissions will follow the LSP admissions model of either pre-major and/or direct-enroll framework (as it rolls out college wide), we plan to admit the first classes of students into the NE major as students electing to switch into the NE major from other majors in the college of engineering. This approach of admitting small classes of students will allow us to more quickly admit students to the major when compared to the NFYS admissions model and, therefore, more quickly develop and refine the new undergraduate curriculum. This phased approach to starting a new major is similar to the process that Biomedical Engineering used when they started their undergraduate major.

**Faculty Table**

| Name | Title |
|---|---|
| Raymond Cao | Professor |
| Tunc Aldemir | Professor |
| Rich Denning | Professor Emeritus |
| Praneeth Kandlakunta | Research Assistant Professor |
| Marat Khafizov | Associate Professor |
| Carol Smidts | Professor |

| | |
|---|---|
| Richard Vasquez | Assistant Professor |
| Dean Wang | Associate Professor |
| Sarah Wolff | Assistant Professor |
| Taiyang Zhang | Assistant Professor |
| TBD | Assistant Tenure Track Professor |
| TBD | Assistant Professor of Practice |

THE OHIO STATE UNIVERSITY

College of Engineering

Undergraduate Education & Student Services

122 Hitchcock Hall
2070 Neil Avenue
Columbus, OH 43210-1278

614-292-2651 Phone
614-292-9379 Fax

engineering.osu.edu

# Memo

To: Randy Smith, Vice Provost for Academic Programs, Office of Academic Affairs
From: Cory Matyas, Assistant Dean for Curriculum and Assessment
Date: April 8, 2026
Re: Proposed Bachelor of Science in Nuclear Engineering

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Please find enclosed a proposal requesting approval to establish a Bachelor of Science in Nuclear Engineering undergraduate major within the Department of Mechanical and Aerospace Engineering in the College of Engineering. This new degree program leverages the university's existing strengths in nuclear engineering, including established graduate programs, faculty expertise, and unique facilities, to address growing workforce and educational needs in nuclear science and engineering in Ohio and nationally.

The proposed program requests an effective start date of Autumn 2026 and is designed to align with institutional priorities, accreditation expectations, and state and industry demand. We respectfully submit this proposal for Council on Academic Affairs review and consideration.

The Engineering College Committee on Academic Affairs met on March 25, 2025 and reviewed this proposal. A vote was taken and the request was unanimously approved. A College-level record of support for this proposal was created.

Ohio Department of Higher Education

Mike DeWine, Governor
Randy Gardner, Chancellor

Draft February 8, 2025

**REQUEST FOR APPROVAL**

**SUBMITTED BY:**

**The Ohio State University**

**Bachelor of Science in Nuclear Engineering, Nuclear Engineering Program/ Department of Mechanical and Aerospace Engineering**

**Date of Submission March 1, 2025 (TBD)**

https://oaa.osu.edu/council-academic-affairs/proposal-submission-guidelines

25 South Front Street
Columbus, Ohio 43215
phone 614.466.6000
fax 614.466.5866
web **www.OhioHigherEd.org**

## REQUEST

**Name of institution: The Ohio State University**

Degree/degree program title: Bachelor of Science in Nuclear Engineering/Nuclear Engineering Program/Department of Mechanical and Aerospace Engineering

**Six-digit CIP code: 14.2301**

Approved/existing programs with same first two CIP code digits (format: CIP code, program name): Aerospace Engineering; Biomedical Engineering; Chemical Engineering; Civil Engineering; Computer Science and Engineering; Electrical and Computer Engineering; Engineering Physics; Engineering Technology; Environmental Engineering; Food, Agricultural and Biological Engineering; Industrial and Systems Engineering; Materials Science and Engineering; Mechanical Engineering; Welding Engineering.
**Total Number of Hours in Program:**

**Primary institutional contact for the request**
**Name: Marat Khafizov**
**Title: Chair-Elect, Nuclear Engineering Program**
**Phone number: (614) 292-2544**
**E-mail: khafizov.1@osu.edu**

**Delivery sites:**
Columbus

**Date that the request was approved by the institution's governing board (e.g. Board of Trustees, Board of Directors):**
TBD

**Proposed start date:**
Autumn 2026

**Institution's programs:** *(e.g., associate, bachelor's, master's, doctorate)*
Currently Master's and Doctorate and undergraduate minor in Nuclear Engineering; Planning to add Bachelor of Nuclear Engineering

**Educator Preparation Programs:**

**Licensure** ***No***

**Endorsement** ***No***

## SECTION 1: INTRODUCTION

**1.1** Ohio has been a manufacturing center of the U.S. nuclear industry, including the development and deployment of nuclear reactors, nuclear equipment manufacturers, space nuclear applications, and uranium enrichment. Despite this leadership position in the industry and being the seventh most populated state in the US, Ohio does not offer a nuclear engineering (NE) undergraduate (UG) major at any of its universities. The US News & World Report top-10 ranked NE programs in the country all have an UG programs. The Nuclear Engineering Program (NEP) at The Ohio State University (OSU) offers graduate degrees (currently 15 Ph.D. students) and a NE minor degree (currently 71 UG students, 17 graduated in May of 2024). Although previously highly ranked, in recent years the ranking of OSU's nuclear program has dropped to number 16 in the country, largely as the result of not having an UG program.

The time is ripe to create a Nuclear Engineering Undergraduate (Major) Program (NEUGP) within the current academic structure at OSU because of the opportunity to meet demands from the nuclear industry that are aligned with university initiatives (JobsOhio). An indication of the recognition of the State government of the future potential of NE within Ohio is the recent appointment by the Governor of the Ohio Nuclear Development Authority. This program will serve not only as a feeder to the graduate program but also provide a pipeline of qualified people with the technical background required to support the regrowth of Ohio's nuclear industry, while also supporting key workforce development areas designated by the State. There are two primary drivers for an increased demand for nuclear engineers: aging of the workforce for the operation of existing nuclear power plants (with planned life extensions to 80 years) and the anticipated deployment of advanced nuclear power plants. Recognizing the growing problem of providing new nuclear engineers with adequate credentials to operate existing plants, in 2024 the Department of Energy (DOE) initiated a $100 million initiative to support nuclear power plant (NPP) workforce training with potential awards as large as $40 million.[1] The size of the initiative is indicative of the concern of the DOE regarding the availability of NPP staff. In the DOE planning document "*Pathways to Commercial Liftoff: Advanced Nuclear*,"[2] the DOE projects that nuclear capacity in the U.S. could triple by 2050, further providing a demand for engineers with nuclear training. Satisfaction of this demand provides a major motivation for establishing an NEUGP. Engineers with UG NE are needed not only to combat climate change in supporting carbon-free electricity production, but they are also highly needed to pursue non-electric applications. These applications include space nuclear power (as we explore and exploit natural resources of the planets, nuclear power will take us there and support operations), process heat applications (including desalination and hydrogen production), medical diagnostics and therapies using radiation and radioisotopes, nuclear non-proliferation technologies, and food preservation.

A survey was undertaken by the OSU NE Program (NEP) faculty to benchmark existing UGNE programs at institutions comparable to OSU. The results of that survey are provided in Appendix A. The assessed demand for an UG major in NE is based on this benchmark exercise. It is likely that a latent demand exists for at least 160 total enrolled undergraduates in the current OSU NEP. As discussed above, we expect a high interest of new students in addressing alternatives for greenhouse-gas-emitting sources for energy supply. Furthermore, the publicity associated with new advanced reactor demonstration plants (passively

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[1] USDOE, "Nuclear Reactor Safety Training and Workforce Development Program," Funding Opportunity Announcement DE-FOA-0003410, September 30, 2024.
[2] USDOE, "Pathways to Commercial Liftoff: Advanced Nuclear," Section 3.c.i. Workforce, March 2023.

safe light water reactors, molten salt reactors, sodium-cooled fast reactor, high-temperature gas-cooled) and small-sized reactors with plans for construction in the next few years will stimulate additional interest and demand for nuclear engineering graduates.

Although a principal component of the demand for NE graduates is related to the design and operation of nuclear power reactors. Nuclear engineering skills also provide the basis for a number of varied employment opportunities. A review was undertaken of the variety of occupations for which an UG NE degree has value, as described in Appendix B.

In addition to the replacement of fossil fuel sources of greenhouse gases, a variety of space-missions to provide greater National Security in CisLunar space (the region between the earth and the moon), as well as science and exploration missions to the planets over the next decades will require nuclear power for propulsion,[3] as well as serving as the energy source for surface-based activities to include higher-capability rovers, and atmospheric flight vehicles (e.g., the NASA Dragonfly mission to Saturn's Moon, Titan.[4] There will also be increasing demand for engineers with experience in medical radiation source applications.

The total 160 UG enrollment goal for the NE major is consistent with other units within the College of Engineering (COE) for disciplines outside the standard engineering disciplines of mechanical engineering, electrical engineering and civil engineering, e.g., the total UG enrollment in AU25 was 554 in the Aerospace Engineering program, 310 in the Biomedical Engineering Department, and 176 in the Materials Science and Engineering Department. Based on this internal comparison as well as the external benchmarking (in Appendix A), we believe the goal of total UG enrollment, once achieved, will bring the NE national ranking into the top 10.

The planned start date for the program is Fall of 2025. We anticipate new undergraduate student enrollment per year to be about ~20 in 2026, ~30 in 2027, and over 40 added per year thereafter, with a goal of 160 total UG enrollment.

## SECTION 2: ACCREDITATION

Sections 2.1 through 2.3 below delineate the steps in the accreditation process:

### 2.1 Regional accreditation

- The existing NE graduate program and undergraduate minor are not subject to accreditation requirements.
- The details of the ABET accreditation program do not need to be developed until after the program has been initiated
- The planned program has been developed to satisfy ABET criteria for NEUGPs[5].

[3] https://www.nasa.gov/space-technology-mission-directorate/tdm/space-nuclear-propulsion/

[4] R.D. Lorenz et al., "Dragonfly: A Rotocraft Lander Concept for Scientific Exploration at Titan", Johns Hopkins Technical Digest, 34, 2018.

[5] https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2022-2023/

**2.2 Results of the last accreditation review – Not applicable at this time.**

**2.3 Notification of appropriate agencies**

- *Provide a statement indicating that the appropriate agencies (e.g., regional accreditors, specialized accreditors, state agencies, etc.) have been notified of the institution's request for authorization of the new program.* ***Provide documentation of the notification as an appendix item.***

  A statement of notification to appropriate agencies is provided as Appendix C (TBD after Department approval).

## SECTION 3: LEADERSHIP—INSTITUTION

Section 3.1 provides the mission statement. Organizational structure is described in Section 3.2

**3.1 Mission statement**

The university is dedicated to:

- Creating and discovering knowledge to improve the well-being of our local, state, regional, national and global communities;
- Educating students through a comprehensive array of distinguished academic programs;
- Preparing a diverse student body to be leaders and engaged citizens;
- Fostering a culture of engagement and service.

We understand that diversity and inclusion are essential components of our excellence.

**3.2 Organizational structure**

A diagram of the OSU organizational structure is provided in Appendix D. The NEP is an element of the Department of Mechanical and Aerospace Engineering (It is anticipated that after the NEUGP is approved, the name of the department will be changed to Mechanical, Aerospace and Nuclear Engineering, which is typical of a number of other universities with UG NEPs.) The Chair of the current OSU NEP reports to the Chair of the Mechanical and Aerospace Engineering, who in turn reports to the Dean of Engineering. Although historically at times the Director of the Reactor Laboratory and the Director of the Nuclear Engineering Program have been the same individual, the Nuclear Reactor Laboratory officially reports to the Dean of Engineering. The U.S. Nuclear Regulatory Commission (NRC) requires a high level of management responsibility in the operation of the reactor.

## SECTION 4: ACADEMIC LEADERSHIP—PROGRAM

Organizational structure is described in Section 4.1. Section 4.2 describes program development. Needs assessment and market analysis is provided in Section 4.3. Section 4.4 describes alignment with Ohio's Workforce Development Program. Input from consultation with advisory groups is described in Section 4.5. Section 4.6 describes the accreditation process. General education requirements are listed in Section 4.6 and projected collaboration with other Ohio institutions is described in Section 4.7. Section 4.8 describes collaboration with other Ohio institutions.

**4.1 Organizational structure**

As described in the preceding section and illustrated in Appendix D, the NEP falls organizationally within the Department of Mechanical and Aerospace Engineering which is within the OSU COE. Consistent with a long-standing objective, it is intended that the name of the Department will be changed to Department of Mechanical, Aerospace and Nuclear Engineering.

The lead administrator for the proposed program will be the Chair of the Nuclear Engineering Graduate Studies Program. The current chair of the program is Professor Tunc Aldemir, whose resume is provided in Appendix E. The lead administrator would have overall responsibility for administration of the NE graduate program, undergraduate major and undergraduate minor programs under the direction of the Department Chair. The lead administrator would represent OSU on a national committee of Nuclear Engineering Program Heads. The current NEP has an independent Nuclear Engineering Advisory Board (NEAB) is comprised of NE faculty from other institutions and senior management of NE government laboratories and nuclear power plant operating organizations. The NEAB meets at least once per year to review program accomplishments and plans.

**4.2 Program development**

The proposed program has been developed consistent with the stated missions of the university:

- Creating and discovering knowledge to improve the well-being of our local, state, regional, national and global communities; Ohio has historically been a major supplier of nuclear equipment, as well as being the site of nuclear facilities for both civilian and military application. Graduates of the OSU UG NEP will be expected to support Ohio's nuclear industrial activities, including the American Centrifuge Project in Piketon, Ohio, nuclear medicine, or continue their education in the graduate nuclear engineering program.

- Educating students through a comprehensive array of distinguished academic programs; Nuclear power is expected to be a major component of the nation's program to reduce the emission of greenhouse gases. Lack of an UG NEP within the State of Ohio is a major deficiency.

- Preparing a diverse student body to be leaders and engaged citizens; OSU nuclear engineering graduate students have been encouraged to become actively involved in society activities that advance nuclear research. Historically, the current OSU NEP has interacted closely with Wilberforce University and Central State College and the Air Force Institute of Technology. The existence of an UG NEP would substantially improve the opportunities for collaborative activities.

- Fostering a culture of engagement and service.

  The current NEP has strongly encouraged involvement of our graduates in society activities. This has resulted in a number of our graduate students in leadership roles on American Nuclear Society committees, as well as Chairing the American Nuclear Society.

**4.3 Needs assessment and market analysis**

The needs assessment and market analysis, which is described in Appendix B, involved a number of elements. The first element was to determine business and academic opportunities within the State of Ohio for people graduating with an UGNE degree. In addition to taking the next step in obtaining a NE graduate degree (improving the strength of our current program), we identified a large number of future educational and business opportunities, beyond satisfying the operating needs of a growing number of nuclear plants for operating and technical support staff. These include radiation applications in the medical field, non-reactor nuclear facility operations, as at the Centrus uranium enrichment facility, and manufacturing facilities for nuclear power plant components. The second element was to gauge the future health of nuclear power in response to concerns about global warming. Our AB provided strong support to the likelihood that the expected rebirth of nuclear power based on advanced reactor and small modular reactors will lead to a rebirth of the industry, as well as the continuing need to support the existing fleet of reactors. The anti-nuclear public concerns associated with the Fukushima accident have largely been replaced in the public eye because of the lack of evidence of associated health effects in the Japanese population and growing concerns about global warming. [6] Although renewable energy sources, solar and wind power, will have major roles in the replacement of fossil fuels, their variability in output make it difficult to integrate them into an electric grid without a baseline source of nuclear generation. Nuclear power is also likely to be a major contributor to economic hydrogen generation in support of industrial energy and transportation needs. Finally, we have benchmarked existing nuclear engineering programs in the U.S. to determine the size of their undergraduate programs (See Appendix D).

Based on the benchmark exercise, it is likely that a latent demand exists for at least 160 total enrolled undergraduates in the UG NEP. As discussed above, we expect a high interest of new students in addressing alternatives for greenhouse-gas-emitting sources for energy supply. Furthermore, the publicity associated with new advanced reactor demonstration plants (passively safe light water reactors, molten salt reactors, sodium-cooled fast reactor, high-temperature gas-cooled) and small-sized reactors with plans for construction in the next few years will stimulate additional interests and demand for nuclear engineering. Space-missions to provide greater National Security in Cis-Lunar space, as well as science and exploration missions to the planets over the next decade will require nuclear power for propulsion, as well as serving as the energy source for surface-based activities to include higher-capability rovers, and atmospheric flight vehicles (e.g., the NASA Dragonfly mission to Saturn's Moon Titan). There will also be increasing demand for engineers with experience in medical radiation source applications.

The diversity of nuclear applications and the interests of potential undergraduates assures that we are likely to experience a strong demand for the proposed Program at or above the levels sufficient to establish a NEUG Program. The developed core course and technical electives will meet the demands for students who chose their further career from broad applications of nuclear science and engineering.

### **4.4 Alignment with Ohio's Workforce Development Program**

The proposed Program directly supports the State's Workforce Development program.[7] Within this program The Choose Ohio First initiative aims to retain our highest quality graduates within Ohio with high paying jobs. Alternative energy supply is one of the areas highlighted for future growth within the program. Based on 2023 data, an entry level student with a Bachelor of Arts degree can expect to make $45,000 (median) in Ohio. In contrast, an entry level student with a Bachelor of Nuclear Engineering degree could expect to make $77,000 (median) in Ohio. A number of students who have taken the NE UG minor degree have been hired by First Energy (now Harbor Energy) for positions at their NPPs. Historically, our students with PhD degrees in NE have tended to leave the state to work at national laboratories, the NRC or teaching positions at other universities with nuclear programs. Ohio has also historically been a

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[6] IPCC, Sixth Assessment Report, "Synthesis Report," March 20, 2023.

[7] https://development.ohio.gov/business/workforce-development

supplier of nuclear equipment.  Individuals with a Bachelor of Nuclear Engineering could provide the workforce for a revitalized nuclear equipment supply industry.  The advanced reactor design concepts under development will be manufactured in facilities, rather than requiring significant on-site construction and assembly.  It is our plan to attempt to attract nuclear plant design organizations to establish manufacturing facilities in Ohio, such as those in Barberton, Ohio operated by BWXT for naval reactors.

A few industries located in the state of Ohio that have nuclear workforce needs are listed below.

1. BWXT Nuclear Operations Group, Inc.'s (BWXT NOG) facility in Barberton, Ohio specializes in the design and manufacture of large, heavy components for naval nuclear reactors, which are used to power and propel U.S. Navy submarines and aircraft carriers.
2. Centrus Energy Corp. operates in Piketon, Ohio, where it recently began uranium enrichment operations. This is the first U.S.-owned uranium enrichment plant to start production in decades. Centrus focuses on producing High-Assay Low-Enriched Uranium (HALEU), which is essential for the next generation of nuclear reactors.  Centrus is particularly interested in students with basic training in criticality safety, materials control and accountability and health physics.
3. NASA Plum Brook Station has transformed from farmland to a gun powder production site, then to a nuclear testing reactor, and finally back to a greenfield—all within a short 70-year span. It remains a potential nuclear testing site in northwest Ohio.
4. US Nuclear Corp. has a subsidiary in Milford, Ohio, called Overhoff Technology Corp., which specializes in manufacturing tritium monitoring instruments. The company is expanding its operations in Ohio due to the increasing demand for its nuclear-related products.
5. Oklo Inc., an advanced nuclear power company, is planning to develop two nuclear power plants in Southern Ohio. These plants are part of Oklo's initiative to create small modular reactors for cleaner energy production.
6. Saint-Gobain has operations in Ohio related to the nuclear industry, specifically through their performance ceramics and refractories division. This division supplies critical components for nuclear reactors, such as high-purity alumina refractories used in the lining of sintering furnaces for nuclear fuel pellets. Additionally, Saint-Gobain has historically produced scintillation and photonic crystals for radiation detection applications, though this business was recently acquired by Luxium Solutions.
7. Reuter-Stokes is a GE division based in Twinsburg, Ohio, that specializes in radiation detection technologies. They produce a variety of instruments, including fission chambers, neutron detectors, and gamma detectors, used in nuclear power plants, research reactors, and other radiation monitoring applications.
8. The Neutron Absorber Material is at the heart of used fuel storage and transport devices such as fuel racks and dry storage casks. Holtec produces its own neutron absorber material in a long-term teaming alliance with Orrvilon, Inc. of Ohio.
9. Edison Welding Institute (located adjacent to OSU) operated the Nuclear Manufacturers Consortium for a number of years.
10. Ohio State University Nuclear Reactor Lab operates the only research reactor in the state, and is a DOE user facility, serving many industrial, research and education.
11. AtkinsRealis is a large business operating in the DOE nuclear engineering and operations space and has expertise in handling and processing tritium.

## 4.5 Consultation with Advisory Groups

The NEAB is largely composed of senior representatives from the nuclear industry, federal research laboratories, other universities with nuclear programs, and the NRC. The NEAB has recognized the value of an undergraduate nuclear engineering program to the State of Ohio and to the ability of the OSU NEP to grow in size and reputation. All of the NE programs in the U.S. that rank above the Ohio State program have undergraduate programs. At the April 29, 2022 meeting, the NEAB urged the program to move more rapidly in adopting an undergraduate minor program. A discussion of barriers to the initiation of the undergraduate major occurred in the 2023 NEAB meeting. The principal barrier had been associated with authorization of new hires. Over the past year that barrier was lifted. In 2024 an additional tenure track faculty member was hired. A search was undertaken to hire a non-tenure track faculty member with focus on teaching undergraduate courses. That search was unsuccessful. It is clear that the population of qualified nuclear engineers with graduate level degrees available within central Ohio is very limited. As a result, our search for faculty to teach undergraduate nuclear engineering courses will focus on junior tenure track faculty.

## 4.6 Accreditation

Undergraduate NEPs in the US obtain ABET accreditation. The proposed UG NEP content has been developed to be consistent with ABET accreditation. One of our former students, who was a former President of the American Nuclear Society and was a former member of the Advisory Committee, has had extensive involvement in the ABET accreditation process and has volunteered to help us with the process. The accreditation process is an 18-month process but requires the accumulation of data on the performance of the program in achieving specified objectives. Thus, it is not clear at this time, when the formal process will be initiated but each of the courses in the program will have to be demonstrated prior to the evaluation.

For Nuclear Engineering the lead society is the American Nuclear Society. The program must include the following curricular topics in sufficient depth for engineering practice:

(a) mathematics, to support analyses of complex nuclear or radiological problems,
(b) atomic and nuclear physics,
(c) transport and interaction of radiation with matter,
(d) nuclear or radiological systems and processes,
(e) nuclear fuel cycles,
(f) nuclear radiation detection and measurement,
(g) nuclear or radiological system design.

The program must also demonstrate that faculty members primarily committed to the program have current knowledge of nuclear or radiological engineering by education or experience.

The proposed curricular program has been developed to assure compliance with these requirements. Appendix C aligns ABET requirements with the proposed course topics.

## 4.7 General Education Requirements

The OSU is committed to educating students for life as well as for their future careers. The university's General Education (GE) requirements are a vital piece of their education that every undergraduate student at Ohio State shares, regardless of major. The GE is a three-part program requiring 32 to 39 credit hours[8]:

1. Bookend courses (2 hours) Students take a launch seminar and a concluding reflection seminar. In the NE undergraduate major program, the concluding seminar is provided through the capstone design course in their senior year.
2. Foundation courses (22 to 25 hours). Students take one course in each of seven disciplines: 1. Race, Ethnicity and Gender Diversity, 2. Social and Behavioral Sciences, 3. Historical and Cultural Studies, 4. Writing and Information Literacy, 5. Literary, Visual and Performing Arts, 6. Natural Sciences, 7. Mathematical and Quantitative Reasoning.
3. Theme Courses (8-12 hours). All students take Citizenship for a Diverse and Just World (4-6 hours) and one additional (4-6 hour) theme: Level Environments, Sustainability, or Health and Well-Being

## 4.8 Collaboration with other Ohio institutions

There are no other institutions in Ohio that offer a bachelor's degree in Nuclear Engineering. The OSU NEP historically had relations with a number of other institutions in Ohio that have varied in intensity with time. The NEP at the University of Cincinnati shared a lecture series with OSU until the Cincinnati program was cancelled. The Air Force Institute of Technology (AFIT) performs nuclear training that is nuclear weapon-related. Nevertheless, our planned undergraduate program in combination with ROTC would provide attractive candidates for graduate work at AFIT. The University of Toledo has close association with the Davis-Besse Nuclear Power Plant. Both OSU and University of Toledo faculty are members of the Michigan-Ohio Branch of the American Nuclear Society and have periodic collaboration. Cleveland State University has historically had close ties with NASA. It is anticipated that the growing application of nuclear power for space missions will result in increased collaboration between the two universities. Central State University COE , Science, Technology and Agriculture offers a minor in Nuclear Engineering. A decade ago the NRC provided support for NE faculty at OSU to provide lectures for that minor. An undergraduate nuclear engineering course at OSU could more effectively enable interaction in the future.

## 5. Student Services

Section 5.1 describes admissions policies and procedures in NE Major. Student academic and administrative services are described in Sections 5.2 and 5.3, respectively.

### 5.1 Admissions policies and procedures

The OSU Engineering College has implemented an admit to major process that utilizes one application for all engineering programs. This process goes beyond the traditional grade metric and incorporates a multi-factor review. Additionally, updated eligibility requirements will allow students to apply to a major earlier, which, for most students, will be the second semester of enrollment.

Students will be admitted based on background and thought that demonstrate:

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[8] https://advising.engineering.osu.edu/current-students/curriculum/general-education

- Capacity to understand basic engineering principles and apply them in a variety of settings
- Informed desire for an engineering discipline
- Appreciation for inclusion, collaboration, leadership, and integrity
- Drive to acquire and apply knowledge to enrich one's life, work, community, and society

Recognizing the challenges in meeting the demand and space availability in popular majors, applicants will choose three majors of interest. In the OSU COE, students will have the opportunity to explore multiple majors through both their coursework and opportunities to engage with faculty, academic advisors, and peers.

Students will select and apply to three majors of interest (ranked in order of preference), during the semester that eligibility courses are completed, which generally occurs during the second semester of enrollment. The process requires students to verify their coursework and respond to a few short essay prompts (about 250 words each). Students will address their interest in the three selected majors, their experiences working with teams, and their life experiences influencing their desire to pursue engineering.

Once final grades are available at the end of the semester, applications will undergo a program review. Applications will be reviewed in the order of their preferred major choices.

All students will be notified of their admission decision on the admission decision date. Admitted students will be offered a place in one major. This offer must be accepted by the indicated deadline to secure a place. Failure to do so may result in cancellation of the admission offer.

The transfer credit policy is consistent with the university policy. Non-remedial coursework completed with a C- or better will be accepted for transfer credit if it is completed at domestic institutions holding regional accreditation or a certificate of authorization from the State of Ohio or at international institutions recognized by their country's ministry of education. In some cases, coursework completed with a grade of D may be accepted. Coursework completed at institutions holding non-regional accreditation may be eligible for transfer credit through the credit by validation process. Coursework from unaccredited institutions or those not holding a certificate of authorization from the State of Ohio, will not transfer.

**5.2 Student administrative services**

The addition of a nuclear engineering major program would have minimal impact on the university's capability to provide student administrative services. One of the nuclear engineering faculty members will be designated as undergraduate major advisor. That individual will be responsible for the periodic review of the progress of the students.

**5.3 Student academic services**

The addition of a nuclear engineering major program would have minimal impact on the university's capability to provide student academic services.

**6.0 Curriculum**

Section 6.1 gives a brief overview o the motivation for an NE Undergraduate Program. Program goals and objectives are described in Section 6.2. Section 6.3 provides a list of course offerings and their descriptions.

### 6.1 Introduction

An undergraduate degree in nuclear engineering at OSU provides the first step to a number of career opportunities including: designing, constructing and operating nuclear power plants; designing and undertaking nuclear aerospace missions; defense related positions in one of the military services; obtaining certification as a health physicist in collaboration with the OSU medical school; advanced degrees leading to research opportunities at research laboratories, private institutions and universities; officer in a military service (including benefits associated with participation in an ROTC program); radiologist or radiologic technician; nuclear reactor regulation. OSU operates a 500 kilowatt nuclear reactor for research and teaching purposes, as well as a radiologic instrumentation laboratory providing hands-on experience. Individuals will receive advice regarding their choice of elective courses based on their ultimate academic objective.

### 6.2 Program goals and objectives

The goals and objectives are consistent with those specified by ABET as discussed earlier for NEPs:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics.
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
3. an ability to communicate effectively with a range of audiences.
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives.
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions.
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.
8. The program must include the following curricular topics in sufficient depth for engineering practice:
   (a) mathematics, to support analyses of complex nuclear or radiological problems,
   (b) atomic and nuclear physics,
   (c) transport and interaction of radiation with matter,
   (d) nuclear or radiological systems and processes, (e) nuclear fuel cycles,
   (f) nuclear radiation detection and measurement,
   (g) nuclear or radiological system design.

The course offerings and periodic evaluations of student progress are consistent with these program objectives.

## 6.3 Course offerings/descriptions

| Course (Name/Number) | No. of Credit Hr | Major/ Core/ Technical | General Education | Elective | OTM, TAG or CT2 | New/Existing Course |
|---|---|---|---|---|---|---|
| Math 1151 (Calculus) | 5 | Core | | | Unknown | Existing |
| MATH 1172 (Engr Math A) | 5 | Core | | | Unknown | Existing |
| MATH 2173 (Engr Math B) | 3 | Core | | | Unknown | Existing |
| MATH 2174 (Lin Alg and Diff Eq) | 3 | Core | | | Unknown | Existing |
| MATSCEN 2010 (Intro to Eng Materials) | 3 | Core | | | Unknown | Existing |
| PHYS 1250 (Mechanics) | 5 | Core | | | Unknown | Existing |
| PHYS 1251 (Optics, Elect and Magnetism) | 5 | Core | | | Unknown | Existing |
| ENGR 1181 (Fund of Engr 1) | 2 | Core | | | Unknown | Existing |
| ENGR 1182 (Fund of Engr 2) | 2 | Core | | | Unknown | Existing |
| ENGR 1100 (Engr Survey) | 1 | Core | | | Unknown | Existing |
| CHEM 1250 (Gen Chem) | 4 | Core | | | Unknown | Existing |
| ECE 2300 (Circuits) | 3 | Core | | | Unknown | Existing |
| MECHENG 2040 (Statics and Mech of Materials) | 3 | Core | | | Unknown | Existing |
| MECHENG 2850 (Numerical Methods) | 3 | Core | | | Unknown | Existing |
| NUCLENG 2500 (NSE at OSU) | 1 | Major | | | No | Existing |
| NUCLENG 4505 (Intro to NSE) | 3 | Major | | | No | Existing |
| NUCLENG 4506 (Rad Detection Laboratory) | 3 | Major | | | No | Existing |
| NUCLENG 4510 (Interaction of Rad with Matter) | 3 | Major | | | No | New |

| | | | | | | |
|---|---|---|---|---|---|---|
| NUCLENG 4701 (Intro Reactor Eng and Physics) | 3 | Major | | | No | Existing |
| NUCLENG 4520 (Rad Detection) | 3 | Major | | | No | New |
| NUCLENG 4530 (Nuc Reactor Operations) | 3 | Major | | | No | New |
| NUCLENG 4536 (Nucl Reactor Systems) | 3 | Major | | | No | Existing |
| NUCLENG 4570 (Health Physics) | 3 | Major | | | No | New |
| NUCLENG 4540 (Rad Detection Laboratory) | 3 | Major | | | No | New |
| NUCLENG 4580 (Capstone Design I) | 3 | Major | | | No | New |
| NUCLENG 4581 (Capstone Design II) | 3 | Major | | | No | New |

Course Descriptions

| Course (Name/Number) | Description |
|---|---|
| Math 1151 | Introduction to calculus. |
| MATH 1172 | Engineering mathematics |
| MATH 2173 | Advanced engineering mathematics |
| MATH 2174 | Linear algebra and differential equations |
| MATSCEN 2010 | Mechanics of materials |
| PHYS 1250 | Physical mechanics |
| PHYS 1251 | Optics, electricity and magnetism |
| ENGR 1181 | Fundamentals of engineering I |
| ENGR 1182 | Fundamentals of engineering II |
| ENGR 1100 | General engineering concepts |
| ENGR 1221 | Introduction to computer programming (MATLAB) |
| CHEM 1250 | General chemistry |
| ECE 2300 | Electrical circuits analysis |
| MECHENG 2040 | Statics and dynamics |
| MECHENG 2850 | Numerical methods |
| NUCLENG 2500 | General introduction to nuclear engineering research at OSU |
| NUCLENG 4505 | Broad introduction to nuclear science and engineering |
| NUCLENG 4510 | Interaction of radiation with matter, shielding |
| NUCLENG 4506 | Radiation detection laboratory |
| NUCLENG 4701 | Reactor engineering and physics |
| NUCLENG 4520 | Radiation detection |
| NUCLENG 4530 | Reactor operations |
| NUCLENG 4536 | Nuclear reactor systems and thermal-hydraulics |
| NUCLENG 4570 | Radiation application and measurement, health physics |
| NUCLENG 4580 | Capstone design I |
| NUCLENG 4581 | Capstone design II |

The General Education requirements are a coherent three-part program consisting of:

1. **Bookend courses** (2 hours) Students will take a launch seminar and a concluding reflection seminar to begin and end the GE program. For engineering students, the concluding reflection seminar is a part of your senior capstone design course and will not be a separate requirement.
2. **Foundation courses** (22-25 hours) -- Students will take one course in each of seven distinct disciplines.
3. **Theme courses** (8-12 hours) -- All students will take courses in the *Citizenship for a Diverse and Just World* Theme (4-6 hours) and in one additional Theme of their choosing:
    - Lived Environments (4-6 hours)
    - Sustainability (4-6 hours)
    - Health and Well-being (4-6 hours)

**6.4 Program sequence**

| **Time period** | **Curriculum component** | **Hr** | **Time period** | **Curriculum component** | **Hr** |
|---|---|---|---|---|---|
| **Year 1, Autumn Semester** | Courses/Activities | | **Year 1, Spring Semester** | **Courses/Activities** | |
| | **MATH 1151 (Calculus)** | 5 | | **MATH 1172 (Engr Math A)** | **5** |
| | **PHYSICS 1250 (Mechanics)** | 5 | | **CHEM 1250 (Gen Chem)** | **4** |
| | ENGR 1181 (Fund of Engr 1) | 2 | | **ENGR 1182 (Fund of Eng 2)** | **2** |
| | **ENGR 1100 (Engr Survey)** | 1 | | **ENGR 1221 (Intro Computer Programming)** | **1** |
| | **NUCLENG 2500 (NE Research Survey)** | 1 | | **NUCLENG 4510 (Radiation Interaction with Matter)** | **3** |
| | **GE Foundations** | **3** | | **GE Launch Seminar** | **1** |
| **Credit hours** | | **17** | **Credit hours** | | **16** |
| | | | | | |
| **Time period** | **Curriculum component** | | **Time period** | **Curriculum component** | |
| **Year 2, Fall Semester** | **Courses/Activities** | | **Year 2 Spring Semester** | **Courses/Activities** | |
| | **Physics 1251 Mechs, thermal** | 3 | | **NUCLRENG 4701 (Reactor Phys)** | **3** |
| | **MATH 2173 (Engr Math B)** | 3 | | **MATH 2174 (Ln Alg and Diff Eq)** | **3** |

| | | | | | |
|---|---|---|---|---|---|
| | **CHEM 1250 (Gen Chem)** | 4 | | **MECHENG 2850 (Numerical Methods)** | **3** |
| | STAT 3450 | 3 | | **MATSCEN 2010 (Intro to Engr Materials)** | **3** |
| | **NUCLENG 4505 (Intro to NSE)** | 3 | | **MECHENG 2010 (Statics)** | **3** |
| | **GE Foundations** | 3 | | **GE Foundations** | 3 |
| **Credit hours** | | **19** | **Credit hours** | | **18** |
| | | | | | |
| **Time period** | **Curriculum component** | | **Time period** | **Curriculum component** | |
| **Year 3 Fall Semester** | **Courses/Activities** | | **Year 3 Spring Semester** | **Courses/Activities** | |
| | **MECHENG 3501 (Thermocynamics))** | **3** | | **NUCLENG 3260 (Nuclear Reactor Kinetics and Control)** | **3** |
| | **NUCLENG 4520 (Radiation Detection)** | 3 | | **Eng Elective** | **3** |
| | **NUCLENG 4530 (Nuclear Reactor Operation)** | 3 | | **NUCLENG 4570 (Radiation Application and Health Physics)** | **3** |
| | **NUCLENG 4536 (Mechanical and Thermal Hydraulics Design)** | 3 | | **NUCLENG 4506 (Rad Det Laboratory)** | **3** |
| | **ECE 2300 (Circuits)** | 3 | | **Elective** | **3** |
| | **Elective** | 3 | | **GE Foundations** | **3** |
| **Credit hours** | | **18** | **Credit hours** | | **18** |
| **Time period** | **Curriculum component** | | **Time period** | **Curriculum component** | |
| **Year 4 Fall Semester** | **Courses/Activities** | | **Year 4 Spring Semester** | **Courses/Activities** | |
| | **Nuclear Eng Elective** | 3 | | **Nuclear Eng Elective** | **3** |
| | **Nuclear Eng 4580 Capstone Design I** | 3 | | **Nuclear Eng 4581 Capstone design II** | **3** |
| | **Nuclear Eng Elective** | 3 | | **Nuclear Eng Elective** | **3** |
| | **Elective** | 3 | | **Elective** | **3** |
| | **GE Foundation** | 3 | | **GE - Theme** | **4** |
| **Credit hours** | | **15** | **Credit hours** | | **16** |

Syllabi for required courses are provided in Appendix 6. All classes are required to have syllabi as an OSU requirement. Brief course descriptions for the undergraduate nuclear engineering major program are provided below.

**Brief Nuclear Engineering Course Descriptions:**

**NUCLENG 2500 Nuclear Science and Engineering at OSU.** The course is designed to offer information about careers in Nuclear Sciences and Engineering (NE) and describe NE related opportunities at OSU, including undergraduate research possibilities.

**NUCLENG 4505 Introduction to Nuclear Science and Engineering**: A broad introduction to all aspects of nuclear science and engineering, including power generation, advanced reactor concepts, fuel cycles, radiation detection, shielding, medical application etc.

**NUCLENG 4506 Radiation Detection Laboratory:** Laboratory experience using both analog and digital instrumentation, and use of OSU Research Reactor for flux measurement.

**NUCLENG 4520 Radiation Detection**: Fundamental radiation detection with gas, semiconductor, and scintillator detectors, nuclear instrumentation, applications in medical, homeland security.

**NUCLENG 4530 Nuclear Power Plant Operations:** Examination of procedures for the startup, operation and emergency shutdown of nuclear power plants. Includes use of a simulator for a light water reactor with prototypic wall display panels.

**NUCLENG 4536 Thermal Hydraulics and Engineering Design**: Covers basics in thermodynamics, fluid mechanics, and heat transfer in the context of neutronics and its effect on reactor control feedback.

**NUCLENG 4570 Health Physics**: Radiation shielding, protection, dosimetry, and biological effects.

**NUCLENG 4701 Reactor Physics**: Topics include nuclear data, homogeneous, and heterogeneous resonance absorption, calculation of neutron spectra, determination of group constants, multigroup diffusion theory

**NUCLENG 4580 Capstone Design I:** Design project in senior year.

**NUCLENG 4581 Capstone Design II:** Design project in second semester of senior year.

<u>**Nuclear Engineering Electives**</u>

**Reactor Safety:** Introductory course covering concepts of reactor safety, the history of reactor accidents and methods of safety and risk analysis.

**Materials in Nuclear Systems**: Develop an understanding of the impact of radiation damage on behavior of nuclear fuel, structural and sensor material. Topics include discussion of crystalline structure, defects, damage production, microstructure evolution and impact on physical properties of materials.

**Medical Applications of Radiation and Radioisotopes:** Joint course with Nuclear Engineering Program and the Medical School.

**Nuclear Space Propulsion and Space Reactors**: Introduction to nuclear reactors and radioisotopes for space, nuclear propulsion principles, nuclear thermal rocket propulsion systems, application of ion thrusters, high power and high thrust density electric propulsion for in-space transportation, space reactor designs for electricity generation to support manned and unmanned missions, and nuclear safety and legal regulations

**Computational Methods for Nuclear Engineering**: Aspects of the theory of partial differential equations (PDEs), Boundary value problems (BVPs) and initial-boundary value problems (I-BVPs) for certain linear PDEs of second order, namely; the heat (parabolic), wave (hyperbolic) and Laplace (elliptic) equations, how PDEs are classified into different categories, some aspects of their derivation and techniques for their solutions, Bessel's and Legendre's equations, Fourier analysis, separation of variables, and transform methods. Extensive use computational software MATLAB, SIMULINK, ORIGIN, MAPLE etc.

**Future NUCLENG Elective: Engineering Design of Fusion Reactors**. It is premature to introduce a course in the near future because of uncertainty regarding which fusion concepts will demonstrate positive gain (more energy out than in) to be most feasible. However, within approximately five years many of those uncertainties will be resolved. The economics of fusion power will depend upon the engineering design of the plant within physics constraints.

**6.5 Alternative delivery options (please check all that apply):**

☐ More than 50% of the program will be offered using a fully online delivery model
☐ More than 50% of the program will be offered using a hybrid/blended delivery model
☐ More than 50% of the program will be offered using a flexible or accelerated delivery model

The intended delivery approach is to use a traditional in-class mode of offering. A number of the classes involve laboratories (including the OSU research reactor), instrumentation, hardware or computer tools that require in-class activities.

**6.5 Off-site program components (please check all that apply):**

Not applicable.

## SECTION 7: ASSESSMENT AND EVALUATION

Section 7.1 describes the proposed Program assessment process. Section 7.1 describes how student success will be measured.

**7.1 Program assessment**

Currently the assessment of the NEP is performed by the Department Manager of the Department of Mechanical and Aerospace Engineering, primarily on an annual basis and largely associated with the performance of individual professors based on their teaching ratings (which are collected and evaluated for all classes) and the quality and quantity of their research associated with their promotion and tenure.

For the UG NEP , student evaluations will be based on the assessment of the NE undergraduate advisor with oversight provided by the NEP chair The specific curriculum requirements and bases for assessing student outcomes are derived from ABET requirements. In general, ABET identifies seven specific program outcomes that prepare the graduate to enter professional practice within the general field of engineering:

1. An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics
2. An ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors
3. An ability to communicate effectively with a range of audiences
4. An ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. An ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives
6. An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions
7. An ability to acquire and apply new knowledge as needed, using appropriate learning strategies

In addition, Table 2 identifies the specific nuclear engineering courses that prepare the graduate to enter professional practice specifically in the allied fields of nuclear engineering

- **Table 2: Nuclear Engineering Courses Addressing ABET Outcomes for Graduates in the Allied Fields of Nuclear Engineering**

| • Course(s) | • ABET Student Outcomes | | | | | | |
|---|---|---|---|---|---|---|---|
| | • 1 | • 2 | • 3 | • 4 | • 5 | • 6 | • 7 |
| • NUCLEN G 4505, Introduction to Nuclear Science and Engineering | • X | | • X | • X | | | • X |
| • NUCLEN G 4520, Radiation Detection | • X | • X | | • X | | | • X |
| • NUCLEN G 4506, Radiation Detection Laboratory | • X | • X | | • X | • X | • X | • S |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| • NUCLEN G 4536, Thermal Hydraulics | • X | • X | | • X | | | • X |
| • NUCLEN G 4530 Nuclear Power Plant Operations | • X | • X | | • X | | | • X |
| • NUCLEN G 4570 Health Physics | • X | • X | | • X | • X | | • X |
| • NUCLEN G 4701 Reactor Physics | • X | • X | | • X | | | • X |
| • NUCLEN G, NE Capstone Design I & II | • X | • X | • X | • X | • X | • X | • X |

In each year of the program, data will be collected by the undergraduate program advisor to determine the performance of NE undergraduate students within these courses in support of ABET accreditation. The Nuclear Engineering Program director will take remedial action as indicated.

### 7.2 Measuring student success

The measurement of student progress toward achieving ABET-related goals is performed using a common approach as applied to the other two undergraduate programs in the Mechanical and Aerospace Engineering Department. The designated undergraduate student advisor will be responsible for rating the progress of students in the undergraduate nuclear engineering program. Each student's grades will be reviewed on an annual basis. Corrective action will be taken as appropriate.

## SECTION 8: FACULTY

Faculty appointment policies are described in Section 8.1. Section 8.2 describes the proposed Program faculty makeup. Expectations for professional development/scholarship and faculty matrix are provided in Sections 8.3 and 8.4, respectively.

### 8.1 Faculty appointment policies

The Fall of 2026 is an appropriate target for initiating the program (contingent on the progress of program approval) with the planned hiring of tenure track faculty and lecturers. Most of the courses will be taught by current tenure track faculty. At least one new tenure track faculty member will be added to the faculty prior to initiating the program. Recruiting tenure track faculty began in the current 2025/2026 academic year for two faculty lines, one tenure track with a focus on AI related to Nuclear Engineering and one practice track. All current and future hiring is and will be conducted in accordance with the Strategic Hiring Initiative for Faculty Talent (SHIFT), which is designed to identify and recruit broad, qualified applicant pools of extraordinary scholars who are leaders in their respective fields. Deans, department chairs and search committee members work in partnership with the Office of Faculty Affairs and other key stakeholders in adherence to this framework to ensure a thorough, fair and consistent faculty search process.

**8.2 The Area of Faculty to be recruited and sources of R&D funding:**

*Applied Nuclear Science in Support of Nuclear Non-Proliferation,* including development of radiation sensors bridging with advanced materials and additive manufacturing, detection methods and instrumentation. This individual would be expected to perform research taking advantage of OSU Nuclear Reactor Lab. This position could collaborate closely with department of mechanical and computer engineering, materials science and engineering, and other colleges of arts and science, and college of medicine. **Funding:** DOE, National Nuclear Security Administration (NNSA), DoD/Defense Threat Reduction Agency, Department of Homeland Security, NRC, National Institute of Health, NSF, NASA Potential. **Teaching Responsibilitie**s: NUCLENG Intro to Nucl. Science; NUCLENG Radiation Detection; NUCLENG Radiation Detection Laboratory course taking advantage of the new Radiation Detection Laboratory in Scott Laboratory.

*Risk and Reliability*, including probabilistic risk assessment with focus on system dynamics, uncertainty quantification, security, human reliability, data analytics, and decision optimization, with applications to nuclear systems as well as aerospace systems, autonomous systems and health care. **Funding:** Battelle Energy Alliance (Idaho National Laboratory), Department of Energy, Sandia National Laboratories, The National Aeronautics and Space Administration, the Nuclear Regulatory Commission (NRC), the Department of Energy and the International Atomic Energy Agency. Potential Undergraduate **Teaching Responsibilities**: NUCLENG Reactor Physics; NUCLENG: Nuclear Systems and Analysis; NUCLENG Elective: Computational Methods for Nuclear Engineering

*Experimental Thermal Hydraulics,* including water-cooled light water reactors and advanced non-water reactor designs (molten salt reactors, high temperature gas cooled reactors, sodium-cooled fast reactors), both computational and experimental thermal hydraulic characterizations are at the forefront of maintaining reactor safety: DOE, NASA, NSF, and partner through industry and national labs. Potential. **Teaching Responsibilities**: NUCLENG Thermal hydraulics; NUCLENG Elective: Nuclear Reactor Dynamics and Control:

*Health Physics/Radiological Engineering* with medical physics applications, health physics, radiation imaging, dosimetry, radiation protection and shielding. Presently, OSU NEP's collaborators at the Wexner Medical Center have clinical and diagnostics programs in clinical and research settings and have developed a specialized curriculum in medical physics (Prof. Nilendu Gupta), which includes modules involving external and internal dosimetry, advanced radiobiology, radioecology, radiochemistry, nuclear medicine, radiological physics and medical imaging. This new hire would more tightly establish the relationship between the UGNEP and the subsequent graduate-level medical imaging activities of the Medical College. **Funding:** National Science Foundation, National Institutes of Health, Department of Energy, Defense Advanced Research Projects Agency and Department of Defense Teaching area: NUCLENG Health

Physics; NUCLENG Elective: Radiation Detection, Instrumentation and Sensor Lab; NUCLENG Elective: Nuclear Radiological Engineering

*Space Reactor,* space reactor design (mechanical, nuclear and thermal hydraulics), nuclear thermal propulsion, nuclear-derived surface power, space reactor instrumentation and measurement. This position is well-aligned to leadership assignments found at Ohio-based NASA/Glenn Research Center and Wright Patterson Air Force Base, and is further fortified with the recent issuance of Space Policy Directive #6 in December 2020, articulating the US commitment to nuclear systems in space for power and propulsion. This position has high synergy related to Aerospace Engineering within MAE. New start-up companies for reactor design. Funding: NASA, DOE, Air Force, and partner through industry and national labs. Teaching area: NUCLENG core: Interaction of Radiation with Matter; NUCLENG Elective: Nuclear Space Propulsion and Space Reactors Course

### 8.3 Current NEP Faculty

Current NEP faculty includes eight full-time faculty (excluding two emeritus faculty) are currently available to teach undergraduate courses. During the first two years of the program it is expected that three additional faculty will be added to the program to accommodate expanded teaching assignments.

### 8.4 Expectations for Professional Developent/Scholarship

New faculty will be required to undertake the Drake one-year, evidence-based FIT Teaching and Learning Program. Appendix 7 describes the Promotion and Tenure police\y of the Department of Mechanical and Aerospace Engineering.

### 8.5 Faculty matrix

- *Complete a faculty matrix for the proposed program. A faculty member must be identified for each course that is a required component of the curriculum. If a faculty member has not yet been identified for a course, indicate that as an "open position" and describe the necessary qualifications in the matrix (as shown in the example below). Generally a* ***copy of each faculty member's CV should be included as an appendix item. Please check with ODHE staff to determine if all vita are needed. The vita of the program director should be included. Please do not remove any columns from the table below. All fields are required.***

Biosketches for faculty are provided as Appendix E.

| Name of Instructor | Rank or Title | Full-Time or Part-Time | Degree Titles, Institution, Year<br><br>Include the Discipline/Field as Listed on the Diploma | Years of Teaching Experience In the Discipline/ Field | Additional Expertise in the Discipline/ Field<br><br>(e.g., licenses, certifications, if applicable) | Number of Courses this Individual will Teach Per Year at All Campus Locations |
|---|---|---|---|---|---|---|
| *Lei Raymond Cao* | *Professor* | *FT* | *Experimental Nuclear Physics, Lanzhou Univ, BS 1994* | *25 yr* | Post docs Harvard Med School; | *4* |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | *Nucl and Part Phys, MS, China Inst Atomic Energy, MS 2002 Nucl and Rad Eng, Univ of Texas, PhD 2007* | | National Inst Standards and Technology | |
| *Marat Khafisov* | *Assoc Professor* | *FT* | *Physics, BS, 2001 Mid East Tech Univ, 2001, Physics, MS, Univ of Rochester 2003 Physics, PhD, Univ of Rochester 2008* | *10 yr* | Staff Scientist Idaho National Lab 3 yr. | *4* |
| *Tunc Aldemir* | *Professor* | *FT* | *Math Physics, Diploma, Istanbul Univ,1970 Nucl Engr, MS, Univ of Illinois, 1975 Nucl Engr, PhD, Univ of Illinois, 1978* | *42 yr* | Head Cekmece Nuc Res and Training Center, Turkey 5 yr. | *0* |
| *Carol Smidts* | *Professor* | *FT* | *Eng Phys, BS/MS, Univ Libre de Bruxelles, 1987 Eng Phys, PhD, Univ Libre de Bruxelles, 1991* | *31 yr* | Asst/Assoc Prof, Univ of Maryland 13 yr | *4* |
| *Dean Wang* | *Assoc Professor* | *FT* | *Nuc Engr, BS Harbin Univ, 1995 Nuc Engr, MS Tsinghua Univ, 1998, MS, Reactor Phys and Fuel Man, PhD, 2003* | *10 yr* | Oak Ridge Nat Lab, R&D, 4 yr, Inform Systems Lab, 7yr, Assoc Prof, Univ of Mass Lowell 4 yr | *4* |
| *Richard Vasques* | *Asst Prof* | *FT* | *App and Comp Math, BS, Univ Fed do Rio Grande do Sul, 2002 App Math, MS, Univ do RGdS, 2005 App and Interdisc Math, Univ of Mich 2009.* | *9 yr* | Asst Prof, Fndacao Getulio Vargas Escola 1 yr; Project Scientist within Germany, Brazil and Univ of Calif, Berkeley | *4* |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Praneeth Kandlakunta* | *Res Asst Prof* | *FT* | *Elect and Inst Engineering, BE, Birla Inst of Tech, 2008 Nucl Eng, MS, OSU 2012 Nucl Eng , PhD, OSU 2014* | *1* | Med Phys Post-doc, Wash Univ, 3 yr Nuc Engr, MP Machinery and Testing , 1 yr | *4* |
| *Taiyang Zhang* | *Asst Prof* | *FT* | *University of Illinois* | *0* | | *4* |
| *Thomas Blue* | *Emeritus (Academy) Professor* | | *Phys, Miami U, BS, 1972 Nucl Sci, Univ of Mich, MS, 1973 Nucl Sci, Univ of Mich, PhD, 1978* | *38 yr* | Director OSU Nuclear Reactor Lab, 9 yr | *4* |
| *Richard Denning* | *Emeritus Professor* | | *Bch Eng Phys, 1963, Cornell Univ, MS/PhD 1967* | *25 yr* | OSU Nucl Engr Program Director and Reactor Lab Director 4 yr Sr. Research Leader Battelle, 42 yr. | *4* |
| *Open Position Undergrad Student Advisor* | *Faculty of Practice* | *FT* | *At least a Master's in Nuclear Engineering* | *10 years minimum* | | *7* |
| *To Be Hired Spring 2026* | *Asst Prof* | *FT* | *PhD in NE* | *No minimum* | | 4 |
| *To Be Hired Spring 2026* | *Asst Prof* | *FT* | *PhD in NE* | *No minimum* | | 7 |

## SECTION 9: LIBRARY RESOURCES AND INFORMATION LITERACY

Immediately adjacent to Scott Laboratory is the 18th Avenue Library. This library, which was formerly the Science and Engineering Library, covers astronomy, chemistry and chemical and biomolecular engineering, computer science, engineering, geodetic science, mathematics, patents & trademarks, nuclear engineering, physics and statistics. Reference resources available at the library include access to e-journals. These resources are fully consistent with the needs of the nuclear engineering undergraduate program.

## SECTION 10: BUDGET, RESOURCES, AND FACILITIES

Section 10.1 describes resources and facilities.  Budget/financial planning are provided in Section 10.2.

### 10.1 Resources and facilities

The OSU Nuclear Reactor has instrumentation and a classroom to facilitate the performance of experiments and training associated with use of the reactor.  Recent upgrades have significantly expanded space available for research and educational purposes.  Although limited capability has existed at Scott Laboratory for the purpose of radiological research, a radiological instrumentation laboratory will be available for use by students for educational purposes.

### 10.2 Budget/financial planning

*Complete the table on the following page to describe the financial plan/budget for the first four years of program operation.*

**Fiscal Impact Statement for New Degree Programs**
**Please ensure all columns and fields are completed.**

| | Year 1 | Year 2 | Year 3 | Year 4 |
|---|---|---|---|---|
| | | | | |
| **I. Projected Enrollment** | | | | |
| Head-count full time | 40 | 80 | 120 | 160 |
| Head-count part time | | | | |
| Full Time Equivalent (FTE) enrollment | 40 | 80 | 120 | 160 |
| | | | | |
| **II. Projected Program Income** | | | | |
| Tuition (paid by student or sponsor) | 664,430 | 1,330,000 | 1,983,000 | 2,658,000 |
| Expected state subsidy | 200,000 | 400,000 | 600,000 | 800,000 |
| Externally funded stipends, as applicable | 100,000 | 100,000 | 100,000 | 100,000 |
| Other income (if applicable, describe in narrative section below)(Faculty Research) | 0 | 0 | 300,000 | 300,000 |
| | | | | |
| **Total Projected Program Income** | | | | |
| | | | | |
| **III. Program Expenses** | | | | |
| New Personnel<br>• Instruction (technical, professional and general education )<br>Full: 3 Tenure Track by Year 4 (Year 1 &2: +1, Year 3&4: +2)<br>Part Time ____<br>• Non-instruction (indicate role(s) in narrative section below)<br>Full: 1 Academic Advisor<br>Part time ____ | 150,000<br>90,000 | 155,000<br>92,750 | 480,000<br>95,500 | 494,000<br>98,350 |
| New facilities/building/space renovation (if applicable, describe in narrative section below) | 0 | 0 | 0 | 0 |
| Scholarship/stipend support (if applicable, describe in narrative section below) | | | | |
| Additional library resources (if applicable, describe in narrative section below) | 0 | 0 | 0 | 0 |
| Additional technology or equipment needs (if applicable, describe in narrative section below) | 0 | 0 | 0 | 0 |
| Other expenses (if applicable, describe in narrative section below) (Start-up cost) | 500,000 | 0 | 1,000,000 | 0 |
| | | | | |
| **Total Projected Expense** | | | | |

**Budget Narrative:**
*(Use narrative to provide additional information as needed based on responses above.)*

## APPENDICES

Please list the appendix items submitted as part of the request in the table provided below. Please list the items in the order that they are referred to in the text.

**Please note that the institution is required, at a minimum, to submit the following the items as part of the review:**

Results of recent accreditation reviews
Organizational Chart
Faculty/student handbooks (or link)
Course syllabi
Faculty CVs
Current catalog (or link)

Other items as directed in the supplemental forms (if submitted)

| Appendix Name | Description |
|---|---|
| A. Survey of NE Undergraduate Programs | Results of Survey of 12 top-ranked NE undergraduate programs. |
| B. Occupational Opportunities for NE Undergraduates. | Identification of a variety of occupations requiring nuclear engineering and radiation protection background. |
| C. Statement of Notification | Evidence of notification of state agencies (TBD) |
| D. OSU Organization | Figure showing nuclear engineering program and reactor laboratory within the OSU organizational structure. |
| E. Biosketches of Faculty | Biosketches of current NE faculty including program chair |
| F. Syllabi | General format and specific content of courses to be taught |

**Commitment to Program Delivery**
*Provide a statement of the institution's intent to support the program and assurances that, if the institution decides in the future to close the program, the institution will provide the necessary resources/means for matriculated students to complete their degree.*

**Verification and Signature**
*(Insert name of the institution)* verifies that the information in the application is truthful and accurate.

*Signature of the Chief Presiding Officer or the Chief Academic Officer*
*(Insert name and title of the chief presiding or chief academic officer)*

**Appendix A. Survey of Nuclear Engineering Programs**

The assessed demand for an undergraduate major in NE is based on a benchmark exercise. It is likely that a latent demand exists for at least 160 total enrolled undergraduates in NEP. As discussed above, we expect a high interest of new students in addressing alternatives for greenhouse-gas-emitting sources for energy supply. Furthermore, the publicity associated with new advanced reactor demonstration plants (passively safe light water reactors, molten salt reactors, sodium-cooled fast reactor, high-temperature gas-cooled) and small sized reactors with plans for construction in the next few years will stimulate additional interest and demand for nuclear engineering. In addition to the replacement of fossil fuel sources of greenhouse gases, a variety of space-missions to provide greater National Security in CisLunar space, as well as science and exploration missions to the planets over the next decade will require nuclear power for propulsion, as well as serving as the energy source for surface-based activities to include higher-capability rovers, and atmospheric flight vehicles (e.g., the NASA Dragonfly mission to Saturn's Moon, Titan). There will also be increasing demand for engineers with experience in medical radiation source applications. The diversity of nuclear applications and the interests of potential undergraduates assure us that we are likely to experience a strong demand for this program at or above the levels sufficient to establish a NE Undergraduate program. The developed core courses and technical electives will meet the demands for students who chose to further their careers from broad applications of Nuclear Science and Engineering. Proposed Career Focus Areas for Nuclear Engineering Undergraduate Students can be found in Appendix I. The total 160 UG enrollment goal for the NE major is also consistent with other units within the COE e.g., the total UG enrollment in AU21 was 290 in the Aerospace Engineering program, 269 in the Biomedical Engineering Department, and 153 in the Materials Science and Engineering Department. Based on this internal comparison as well as the external benchmarking (in appendix 2), we believe the goal of total UG enrollment, once achieved, will bring the NE national ranking into the top 10.

This assessment also identified the breadth of employment opportunities for students graduating with a Bachelor of Nuclear Engineering degree.

**Appendix B. Career Focus Areas for Nuclear Engineering Undergraduate Students**

Few freshmen beginning their undergraduate education have a clear understanding of their career objectives. At Ohio State University, engineering students enter a pre-Major program in which they take basic engineering courses and prepare to apply to up to three engineering major programs. This application typically happens during the second semester. Thus, prior to undertaking that application process, the undergraduate Nuclear Engineering (NE) program must make potential applicants aware of the variety of career opportunities they build upon the first step of a bachelor's degree in nuclear engineering. The educational pathways to a number of these career opportunities are described below.

**Educational Pathways to Career Opportunities in the Nuclear Field**

**Nuclear Power Plant Operating Staff**

The staff that operate a nuclear power plant perform a number of functions including control room operations associated with generating electricity, testing of safety systems, equipment maintenance, training of personnel, safety analysis, physical security and waste management. Most of these staff members have undergraduate engineering degrees. Many of the operations at a nuclear plant involve electrical engineering, mechanical engineering and chemical engineering skills in addition to those associated with the nuclear fission process. Thus, an undergraduate nuclear engineering degree with a minor in electrical engineering, mechanical engineering or chemical engineering is particularly attractive to a nuclear utility. At the management level of a plant, a master's degree is typical. The need for doctoral level of nuclear engineering is only likely in highly specialized areas, such as for the performance of core physics analysis or probabilistic risk assessment. In many cases, specialized nuclear skills, such as the design of reload fuel schemes are contracted from service organizations rather than being provided by plant employees.

Educational Pathway – Bachelor of NE (or NE minor with Bachelor of Electrical Engineering, Mechanical Engineering or Chemical Engineering) or Bachelor of Nuclear Engineering followed by Master of NE and in a specialized areas PhD in Nuclear Engineering.

**Reactor Design, Construction, and Service Organizations**

These organizations require a broad range of staff capabilities. Although a design concept typically evolves from innovative research, the realization of a design concept capable of not only satisfying regulatory requirements but also actually producing electricity competitively requires a broad range of technical capability and educational experience. Reactor design organizations, such as Westinghouse or Babcock and Wilcox, require a full spectrum of technical capabilities. Much of the design work is performed at the bachelor's degree level under the supervision of engineers with more advanced degrees. Architect-engineers and construction companies, such as Bechtel, typically rely more on established practice, codes and standards at the level of Bachelor or Master of Engineering disciplines rather than research-oriented engineers. An evolving area of future opportunity is the design of fusion-based electricity generation. Although the physics of magnetic confinement are substantially different from the reactor physics of fission reactors, the engineering challenges for plant design are essentially the same.

Service organizations, such as Nuclear Utility Services (NUS) and MPR Associates, provide technical support services to utilities, such as reload core designs, probabilistic risk assessment tools, which require specialized capabilities outside the range of capabilities of a specific plant staff. There is also a complete supply chain of vendors of equipment for instrumentation and control systems, pumps, valves, and electronic equipment that require people with knowledge not only of the specific equipment, but also the needs of the nuclear power plant.

Educational Pathway – Bachelor of NE, Electrical Engineering, Mechanical Engineering, Civil Engineering, or Chemical Engineering. For specialized applications, a Master's degree or PhD in NE would follow a Bachelor of NE degree. For fusion power plant designs, magnetic confinement principles and concepts will be included within the Bachelor of NE curricula.

**Research Scientist**

Historically, in the United States, some basic research was supported through the private sector at organizations such as Bell Laboratories, IBM, Battelle Memorial Institute and Southwest Research Institute with the intent of developing intellectual property (patents) which could provide a return on investment. Indeed, most companies, like Apple, must continue to perform product improvement research to remain competitive. However, the more basic the research, the cost of research versus the potential financial return is just too high for private industry, except when supported by the federal government or in niche areas such as drug development. In the nuclear field, nuclear-related research is performed at the DOE laboratories (Nuclear Energy Laboratories and Nuclear Weapons Laboratories), NRC, Department of Energy, NASA, National Nuclear Security Administration, and Department of Defense (Army, Navy, Air Force and Space Force). These organizations support research at universities not only to obtain research results but also to train potential future research staff at the Master's degree or Doctoral degree level. Although financial support is available for some undergraduate students, students pursuing advanced degrees in NE almost always receive financial support covering living expenses as well as tuition and fees.

An area of particular future opportunity involves the increased use of nuclear energy in space missions, as a means of propulsion or electricity production. Other opportunities involve advanced reactor development, nuclear non-proliferation, radioactive waste disposal, reactor safety and weapons development. Typically, the research institutes hire either doctoral students or master's level students to perform research.

Educational Pathway – Bachelor of NE, Master's degree in NE, PhD in NE, potentially with a minor in a specialized field such as Aerospace Engineering. An undergraduate NE degree would be followed by an NE master's degree or NE PhD degree with a thesis or dissertation in an area of specialization. U.S. citizens have a distinct advantage in obtaining positions at U.S. national laboratories.

**University Professor**

A principal source of basic research in the nuclear field has been the product of university professors and their graduate students. The competition for university professor positions in the U.S. is severe.

Within the U.S. university system, the roles of teacher and scientist overlap. There are positions available for those who only teach and for those who only do research but, in general, the job description for a professor involves both teaching and performing research. The job description for a university professor involves not only performing research but also training their students how to perform research.

Educational Pathway- Bachelor of NE, Masters in NE, and PhD in NE. Typically, university professors have PhDs and have also performed a Post-Doctoral fellowship at a university. In general, universities do not select their own graduates for tenure track positions. Tenure track professors advance within their ranks from Assistant Professor to Associate Professor to Full Professor based on research and teaching accomplishments. Obtaining tenure provides job security. Other professor roles and pathways are possible for professors who only teach or only do research.

**Officer in a Military Service**

The service most frequently associated with nuclear energy is the Nuclear Navy. Nuclear propulsion of Navy ships is a vital application of nuclear energy because of the need for extended periods at sea both for surface ships or submarines, as well as other advantages relative to fossil fuels that require air and generate production processes. Fortunately, it has never been necessary to implement the tactical use of nuclear weapons in ground warfare but it remains a potential element of the army's military arsenal. Nuclear energy will also play a major role in a space force in addition to non-military space missions.

The Naval Reserve Officer Training Corps provides an opportunity for students to graduate as an officer (ensign) upon graduation with an undergraduate degree. This option is particularly attractive to students with nuclear engineering or nuclear power long-term career objectives. Opportunities exist for NROTC students to receive substantial financial support for their undergraduate degree.

Educational Pathway- Bachelor of NE. Navy Nuclear Power School.

**Certified Health Physicist**

Activities performed with radioactive materials, such as for medical applications, require oversight by certified health physicists (CHP). An organization performing such activities will also have a Radiological Safety Officer to approve and provide oversight of radiological activities, who is a CHP. CHPs are particularly knowledgeable about radiological health effects and the operation of radiological instrumentation. Instrumentation of the types used by CHPs will be provided in a new laboratory planned for Scott Laboratory. A CHP is expected to have at least an undergraduate degree but also must complete a two-part certification process.

Educational Pathway- Bachelor of NE, Master of Nuclear Engineering-HP Option (One-Year Study with Focus on HP Certification Topics).

**Radiologist and Radiologic Technician**

A radiologist is a medical doctor with special expertise in the use of diagnostic equipment (such as X-rays for imaging) and therapeutic equipment. A radiologic technician has expertise in the use of imaging equipment but does not have direct medical expertise. The OSU has major medical research facilities that include advanced and experimental equipment within the Medical School. Imaging techniques have undergone major development in recent years and continue to have a bright future in the diagnosis and treatment of many illnesses including cancer.

Educational Pathway- For a student on track to become a radiologist, after receiving the undergraduate NE degree, the student would transfer to the Medical School. For the more limited activities of radiologic technician, a medical degree is not required.

**Regulatory Authority**

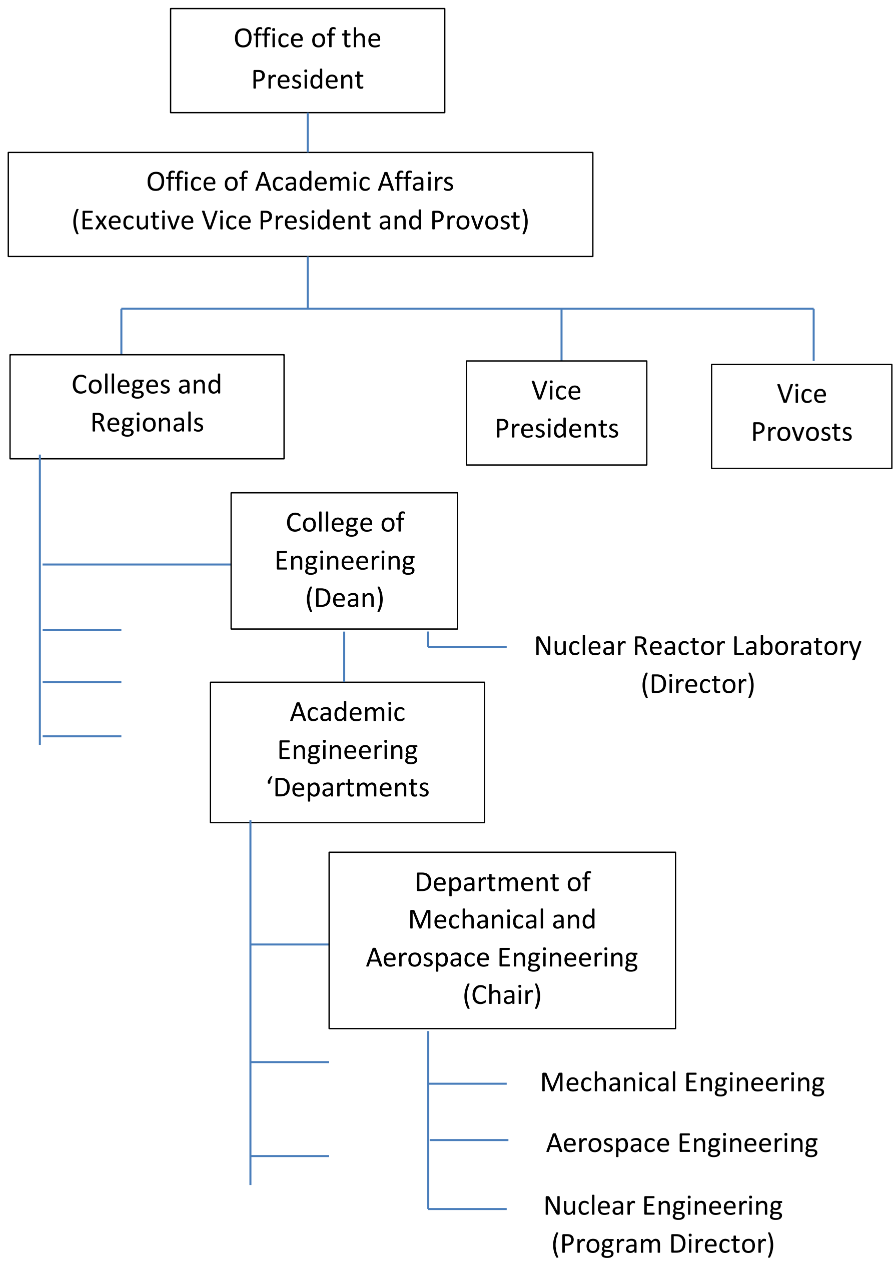
Although some radiological activities fall under the regulatory oversight of the individual states, the regulation of nuclear power plants is performed by the NRC. The NRC licenses new nuclear plants, oversees the safe operation of the plants and their ultimate decommissioning. The NRC offers scholarships for exceptional undergraduate students and fellowships for advanced nuclear engineering degrees. Most research and regulatory activities of the NRC are performed from their headquarters in Maryland. The NRC also has regional offices focused on oversight of power plant operations. These regional offices provide oversight staff who oversee the operation of the plants in-residence. For a number of years, surveys of federal staff have indicated that the NRC is the "best" federal employer.

Educational Pathway- Bachelor of NE, Master of NE, PhD in NE. Hires are made at each educational level.

## Appendix C. Evidence of Notification of State Agencies

TBD

**Appendix D.  NE Program within OSU Organizational Structure**



**Appendix E. Faculty Biosketches**

**Biosketches for the current faculty follow**

**Tunc Aldemir**
E427 Scott Lab, 201 W. 19th Avenue, Columbus, OH 43210
Ph. (614) 292-4627, Email: aldemir.1@osu.edu

**A. Education and Training**

| | | | |
|---|---|---|---|
| University of Illinois | Nuclear Engineering | Ph.D. | 1978 |
| University of Illinois | Nuclear Engineering | M.S. | 1975 |
| Istanbul University | Mathematical Physics | License Diploma | 1970 |

**B. Research and Professional Experience**

| | | | |
|---|---|---|---|
| Professor | OSU | MAE | October 1997 – present |
| Chair | OSU | NEP/MAE | June 2008 – September 2016 |
| Interim Chair | OSU | NEP/MAE | June 2007 – June 2008 |
| Associate Professor | OSU | MAE | October 1989 - October 1997 |
| Assistant Professor | OSU | MAE | September 1983 - October 1989 |
| Head | CNAEM | NED | January 1983 - June 1983 |
| Senior Research Scientist | CNAEM | NED | October 1978 - January 1983 |

CNAEM: Çekmece Nuclear Research and Training Center, Istanbul, Turkey
MAE: Department of Mechanical and Aerospace Engineering NEP: Nuclear Engineering Program
NED: Nuclear Engineering Department OSU: The Ohio State University

**C. Recent Publications (All Peer reviewed)**

1. B. Cohn, T. Noel, D. Osborn, T. Aldemir, "Development of a Leading Simulator/Trailing Simulator Methodology as Part of an Integrated Safety-Security Analysis for Nuclear Power Plants", *J. Risk and Reliability, https://doi.org/10.1177/1748006X221091048* (2022)
2. D. Mandelli, A. Alfonsi, T. Aldemir, "Automatic Generation of Event Trees and Fault Trees: A Model-Based Approach", *Nucl. Technol. https://doi.org/10.1080/00295450.2022.2105780* (2022)

3. J. Kim, A. U. A. Shah, H.- G. Kang, T. Aldemir, “Safety Benefits Assessment For Accident Tolerant Fuels In Consideration Of Steam Generator Tube Degradation Using Dynamic Event Tree Analysis”, *Nucl. Technol.*, 1-18, *https://doi.org/10.1080/00295450.2023.2171271* (2023)
4. B. Cohn, T. Noel, J. Cardoni, T. Haskin, D. Osborn, T. Aldemir, “ Integrated Safety and Security Analysis of Nuclear Power Plants Using Dynamic Event Trees”, *Nucl.Sci.Eng.*,**197:sup1**, S45-S56, *https://doi.org/10.1080/00295639.2023.2177076* (2023)
5. G. S. Turkmen, H. Bao, T Aldemir, “Investigation of the Use of Dynamic Probabilistic Risk Assessment Methodologies for Identifying Digital I&C System Common Cause Failures”,*Proc.18th International Probabilistic Safety Assessment and Analysis (PSA 2023) ,* 200-208, Knoxville, Tennessee (2023)
6. G. S. Turkmen, A. Yilmaz, T. Aldemir, “Machine Learning Based Dynamic Probabilistic Risk Assessment for Multi-Unit Small Modular Reactors”, *PSAM 2023 Conference Proceedings*, https://www.ideals.illinois.edu/collections/2410 (2024)

**D. Synergistic Activities**

- Executive Committee member of the American Nuclear Society Nuclear Installations Safety Division (June 2010 – June 2016)
- Chair, American Nuclear Society, Mathematics and Computation Division (June 2015-June 2016)
- Reviewer for technical journals including *Annals of Nuclear Energy*, *Risk Analysis, Nuclear Engineering and Design*, *Journal of Korean Nuclear Society*, *Journal of Sound and Vibration*, *Nuclear Technology*, *IEEE Transaction on Reliability*, *IEEE Transactions on Nuclear Science*, *Nuclear Science and Engineering* , *Reliability Engineering & System Safety* and several technical meetings.
- Editor of *Proceedings of the International Workshop on Dynamic Reliability,* Center for Risk and Reliability, University of Maryland, College Park, Maryland (2010), *Reliability and Safety Assessment of Dynamic Process Systems*, NATO ASI Series F, Vol.120, Springer-Verlag, Heidelberg (1994), *PSA2002: Proceedings of the International Topical Meeting on Probabilistic Safety Assessment,* American Nuclear Society, La Grange Park, IL (2002) and Guest Editor for the special issue of *Reliability Engineering & System Safety* (Volume 52, Number 3) on the Reliability and Safety Analysis of Dynamic Process Systems (June 1996)
- Member of the editorial board of *Reliability Engineering & System Safety*

**Lei Raymond Cao**

**Education and Training**

| | | | |
|---|---|---|---|
| Lanzhou University | Experimental Nuclear Physics | B.S. | 1994 |
| China Institute of Atomic Energy | Nuclear & Particle Physics | M.S. | 2002 |
| University of Texas at Austin | Nuclear & Radiological Engineering Program | Ph.D. | 2007 |
| Harvard Medical School | Micro Positron Emission Tomography | Post-doc | 2007-2007 |
| National Institute of Standards and Technology | Nuclear instrumentation and materials irradiation & characterization | Post-doc | 2007-2009 |

**Employment History**

| | |
|---|---|
| 2024 - present | Committee, Ohio Nuclear Development Authority |
| 2016 - present | Director, The Ohio State University (OSU) Nuclear Reactor Laboratory |
| 2019 - present | Program Chair, Nuclear Engineering Program, OSU |
| 2018 - present | Professor, Nuclear Engineering Program, OSU |
| 2017 - present | Chief Technology Advisor, Awareability Technologies LLC |
| 2015 - 2018 | Associate Professor, Nuclear Engineering Program, OSU |
| 2009 - 2015 | Assistant Professor, Nuclear Engineering Program, OSU |
| 2007 - 2009 | Research Associate, National Institute of Standards and Technology |

**Peer-Reviewed Publications Most Closely Related (10)**

1. Haotong Wei, Yanjun Fang, Padhraic Mulligan, William Chuirazzi, Hong-Hua Fang, Congcong Wang, Benjamin R. Ecker, Yongli Gao, Maria Antonietta Loi, **Lei Cao**, Jinsong Huang, "Sensitive X-ray detectors made of methylammonium lead tribromide perovskite single crystals," ***Nature Photonics***. Vol. 10, 333–339. 2016. {co-corresponding author]

2. Tsai, Hsinhan, Shreetu Shrestha, Lei Pan, Hsin-Hsiang Huang, Joseph Strzalka, Darrick Williams, Leeyih Wang, **Lei R. Cao**, and Wanyi Nie. "Quasi-2D perovskite crystalline layers for printable direct conversion X-ray imaging." ***Advanced Materials*** (Deerfield Beach, Fla.) (2022): e2106498.
3. Pan, Lei, Yuanxiang Feng, Praneeth Kandlakunta, Jinsong Huang, and **Lei R. Cao**. "Performance of Perovskite $CsPbBr_3$ Single Crystal Detector for Gamma-Ray Detection." ***IEEE Transactions on Nuclear Science*** 67, no. 2 (2020): 443-449. doi: 10.1109/TNS.2020.2964306{Corresponding author; Ranked Top 1 most popular paper in Oct. 2020 issue and top 10 ever since}
4. Pan, Lei, Yuanxiang Feng, Jinsong Huang, and **Lei R. Cao**. "Comparison of Zr, Bi, Ti, and Ga as Metal Contacts in Inorganic Perovskite $CsPbBr_3$ Gamma-Ray Detector." ***IEEE Transactions on Nuclear Science*** 67, no. 10 (2020): 2255-2262. {Corresponding author; Ranked the 3rd most popular paper in Sep. 2020 issue}
5. Wei, Wei, Yang Zhang, Qiang Xu, Haotong Wei, Yanjun Fang, Qi Wang, Yehao Deng, Tao Li, Alexei Gruverman, **Lei Cao** & Jinsong Huang. "Monolithic integration of hybrid perovskite single crystals with heterogenous substrate for highly sensitive X-ray imaging." ***Nature Photonics*** 11, no. 5: 315-321. 2017
6. Lei Pan, Praneeth Kandlakunta, and **Lei R. Cao**. "Inorganic Perovskite CsPbBr 3 Gamma-Ray Detector." In ***Advanced Materials for Radiation Detection***, pp. 33-54. Springer, Cham, 2022.
7. Dong, Qingfeng, Yanjun Fang, Yuchuan Shao, Padhraic Mulligan, Jie Qiu, **Lei Cao**, and Jinsong Huang. "Electron-hole diffusion lengths> 175 µm in solution-grown CH3NH3PbI3 single crystals." ***Science*** 347, no. 6225 (2015): 967-970.
8. Wei, Haotong, Dylan DeSantis, Wei Wei, Yehao Deng, Dengyang Guo, Tom J. Savenije, **Lei Cao**, and Jinsong Huang. "Dopant compensation in alloyed CH 3 NH 3 PbBr 3− x Cl x perovskite single crystals for gamma-ray spectroscopy." ***Nature materials*** 16, no. 8 (2017): 826-833.
9. Liu, Danny X., Jinghui Wang, Ke Pan, Jie Qiu, Marcello Canova, Lei R. Cao, and Anne C. Co. "In situ quantification and visualization of lithium transport with neutrons." ***Angewandte Chemie*** 126, no. 36 (2014): 9652-9656.
10. Yang, Shuang, Zeyuan Xu, Sha Xue, Praneeth Kandlakunta, Lei Cao, and Jinsong Huang, "Organohalide Lead Perovskites: More Stable than Glass under Gamma-Ray Radiation." ***Advanced Materials*** 31, no. 4 (2019): 1805547.

**Awards and Honor**

1. Radiation Science and Technology Award, ANS, 2023
2. IEEE Transactions on Nuclear Science Best Paper Award, 2021
3. Distinguished Graduate Faculty Award, 2022
4. Lumley Research Award, 2015
5. Lumley Research Award, 2013
6. Lumley Interdisciplinary Research Award, 2012
7. U.S. Department of Defense, Young Investigator Award, 2011
8. German Academic Exchange Fellowship, 2003
9. International Atomic Energy Agency (IAEA) Fellowship, 2002
10. Outstanding Master's Thesis Award, CIAE, 2002

**Invention Disclosures and Patent Applications**

1. Lei R. Cao. "Detection devices and methods", United States Patent 9851454B2
2. Lei R. Cao. "Charge generating devices and methods of making use thereof", United States Patent #: 10,451,751

3. Lei R. Cao, Lei Pan. “Charge or electricity generating devices and methods of making and use thereof”, United States Patent Application 20180372891

**Synergistic Activities:**

1. Associate Editor, IEEE Transactions on Nuclear Science
2. Editorial board, Journal of Nuclear Science and Engineering
3. Committee, Ohio Nuclear Development Authority

**CAROL S. SMIDTS**

Nuclear Engineering Program, Department of Mechanical and Aerospace Engineering

The Ohio State University, Columbus, OH 43210

Phone: (614) 292-6727; Fax: (614) 292-3163; E-mail: smidts.1@osu.edu


**Education & Training:**

| | |
|---|---|
| 1991 | École Polytechnique, Université libre de Bruxelles, Belgium, Ph.D. in Engineering Physics. |
| 1986 | École Polytechnique, Université libre de Bruxelles, Belgium, BS/MS in Engineering Physics. |

**Research and Professional Experience:**

| | |
|---|---|
| 2022-Present | Associate Chair for Research, Department of Mechanical and Aerospace Engineering, The Ohio State University, Columbus, Ohio |
| 2016–2019 | Program Director, Nuclear Engineering Program, The Ohio State University, Columbus, Ohio |
| 2008–Present | Professor, Department of Mechanical Engineering, The Ohio State University, Columbus, Ohio. |
| 2002–2008 | Associate Professor, Department of Mechanical Engineering, University of Maryland, College Park, Maryland. |
| 2002 | Visiting Associate Director for Research, Postes Rouges CRNS, LAAS, France (Sabbatical). |
| 2000–2002 | Associate Professor, Department of Materials & Nuclear Engineering, University of Maryland, College Park, Maryland. |
| 2000–2001 | Associate Chair, Reliability Engineering Program, University of Maryland, College Park, Maryland. |
| 1996–2000 | Affiliate Faculty, Institute for Systems Research, University of Maryland, College Park, Maryland. |
| 1994–2000 | Assistant Professor, Department of Materials & Nuclear Engineering, University of Maryland, College Park, Maryland. |
| 12/1992–1994 | Faculty Research Associate, Department of Materials & Nuclear Engineering, University of Maryland, College Park, Maryland. |

06/1992–11/1992 Visiting Scientist, Institute for Systems Engineering & Informatics, JRC, European Communities Commission, Ispra, Italy.

01/1991–11/1992 Faculty Research Associate, École Polytechnique, Université libre de Bruxelles, Belgium.

**Related publications:**

[1] Zhao, Y., Adina, N., Le Blanc, K., Rieger, C., Johnson, B.K., Le, H., McJunkin, T., Vaddi, P-K., Ulrich, T., Li, R., Smidts, C. "Dynamic Probabilistic Risk Assessment for Cyber Security Risk Analysis of the Electric Grid. " ESREL 2020 PSAM 15, November 1-5, 2020, Venice, Italy.
[2] Vaddi, Pavan Kumar, Michael C. Pietrykowski, Diptendu Kar, Xiaoxu Diao, Yunfei Zhao, Timothy Mabry, Indrajit Ray, and Carol Smidts. "Dynamic bayesian networks based abnormal event classifier for nuclear power plants in case of cyber security threats." *Progress in Nuclear Energy* 128 (2020): 103479.
[3] Zhao, Yunfei, Linan Huang, Carol Smidts, and Quanyan Zhu. "Finite-horizon semi-Markov game for time-sensitive attack response and probabilistic risk assessment in nuclear power plants." *Reliability Engineering & System Safety* 201 (2020): 106878.
[4] Zhao, Yunfei, Linan Huang, Carol Smidts, and Quanyan Zhu. "A game theoretic approach for responding to cyber-attacks on nuclear power plants." In *11th Nuclear Plant Instrumentation, Control, and Human-Machine Interface Technologies, NPIC and HMIT 2019*, pp. 399-410. American Nuclear Society, 2019.
[5] Smidts, C., Diao, X., and Vaddi, P., "Next-Generation Architecture and Autonomous Cyber-Defense". *Industrial Control Systems Security and Resiliency.* Springer, Cham, 2019. pp. 203-234.
[6] Smidts, C., Zhao, Y., Diao, X., Ray, I., Hollern, J., Zhu, Q., McJunkin T. "Support for Reactor Operators in Case of Cyber-Security Threats." 2017 ANS Winter Meeting, Washington DC, October 29-November 2, 2017.
[7] Labeau, P. E., Smidts, C., Swaminathan, S., "Dynamic Reliability: Towards an Integrated Platform for Probabilistic Risk Assessment." *Reliability engineering & system safety*, *68*(3), 219-254, 2000.
[8] Swaminathan, S., Smidts, C., "The Event Sequence Diagram Framework for Dynamic Probabilistic Risk Assessment." *Reliability Engineering & System Safety* 63, no. 1 (1999): 73-90.
[9] Devooght, Jacques, and C. Smidts. "Probabilistic reactor dynamics—I: the theory of continuous event trees." *Nuclear science and engineering* 111, no. 3 (1992): 229-240.
[10] Smidts, C., Devooght, J., "Probabilistic Reactor Dynamics—II: a Monte Carlo Study of a Fast Reactor Transient." *Nuclear science and engineering* 111, no. 3 (1992): 241-256.

**Synergistic Activities:**

[1]. Technical Program Chair, PSA 2021;
[2]. Technical Program Co-Chair, NPIC-HMIT 2019;
[3]. Second Vice Chair, ANS Human Factors Instrumentation and Control Division (HFICD);
[4]. Associate Editor for Software Testing Verification and Reliability;

[5]. Co-organizer, Big Data for Nuclear Power Plants Workshop, 2017, 2018, and 2019;
[6]. Co-organizer, the 5th International Workshop on Dynamic Analysis, 2007.

**Major Awards:**

[1]. Fellow, Asia-Pacific Artificial Intelligence Association, 2022;
[2]. Honorary Professorship, Amity University, India, 2019;
[3]. Fellow, Institute of Electrical and Electronics Engineers, 2017.

# MARAT KHAFIZOV, Ph. D.


The Ohio State University
Department of Mechanical and Aerospace Engineering
E420 Scott Lab, 201 W 19th Avenue
Columbus, OH 43210

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Phone: (614) 292-2544
Cell: (585) 503-3314


## EDUCATION

| | | | |
|---|---|---|---|
| Ph.D. | 2008 | Physics | University of Rochester, Rochester, NY, USA |
| M.A. | 2003 | Physics | University of Rochester, Rochester, NY, USA |
| B.S | 2001 | Physics | Middle East Technical University, Ankara, Turkey |

## PROFESSIONAL APPOINTMENTS

| | | |
|---|---|---|
| Associate Professor | 06/2020-current | Department of Mechanical and Aerospace Engineering, The Ohio State University, Columbus, OH, USA |
| Assistant Professor | 08/2014-05/2020 | Department of Mechanical and Aerospace Engineering, The Ohio State University, Columbus, OH, USA |
| Staff Scientist | 03/2010-08/2014 | Department of Materials Science and Engineering, Idaho National Laboratory, Idaho Falls, ID, USA |
| Postdoctoral Scholar | 12/2007-02/2010 | Department of Chemistry, University of Rochester, Rochester, NY, USA |
| Research Associate | 06/2002-11/2007 | Laboratory for Laser Energetics, University of Rochester, Rochester, NY, USA |

## RESEARCH SUMMARY

**The Ohio State University, Associate Professor** **(08/2014-current)**

Thermal Properties of Materials for Extreme Environments

- Understanding the role of radiation damage on physical properties of materials
- Investigation of physical properties of nuclear materials during normal operation, accident conditions and long term storage
- Development of laser based physical property characterization techniques
- Nondestructive evaluation of materials structure using ultrasonic and thermal imaging methods

**Idaho National Laboratory, Staff Scientist** **(03/2010–08/2014)**

Center for Materials Science of Nuclear Fuel

- Understanding the role of irradiation induced damage on thermal transport in nuclear fuel
- Development of laser based non-destructive evaluation techniques for physical properties measurement and microstructure characterization
- Corrosion in nuclear reactor materials

**University of Rochester, Postdoctoral Scholar** **(12/2007–02/2010)**

Exciton dynamics in low-dimensional systems

**University of Rochester, Research Assistant** **(06/2002–11/2007)**

Photoresponse mechanism of superconducting materials

## SELECTED PUBLICATIONS

1. "An integrated experimental and computational investigation of defect and microstructural effects on thermal transport in thorium dioxide", C. A. Dennett, W. R. Deskins, Marat Khafizov, Z. Hua, A. Khanolkar, K. Bawane, L. Fu, J. M. Mann, C. A. Marianetti, L. He, D. H. Hurley, A. El-Azab, *Acta Materialia* **213**, 116934 (2021)
2. "Phase and defect evolution in uranium-nitorgen-oxygen system under irradiation", L. He, M. Khafizov, C. Jiang, B. Tyburska-Püschel, B. Jaques, P. Xu, M. Meyer, K. Sridharan, D. P. Butt, J. Gan, *Acta Materialia* **208**, 116778 (2021)
3. "Assessment of an Empirical Interatomic Potential for Actinide Oxides to Predict Thermal Conductivity in $UO_2$ and $ThO_2$," M. Jin, M. Khafizov, C. Jiang, S. Zhou, C. A. Marianetti, M. S. Bryan, M. E. Manley, and D. Hurley, *J. Physics: Condensed Matter* (2021)
4. "Imaging grains in a model ceramic energy material with optically generated coherent acoustic phonons", Y. Wang, D. H. Hurley, Z. Hua, T. Pezeril, S. Raetz, V. E. Gusev, V. Tournat, M. Khafizov, *Nature Communications* **11**, 1597 (2020)

- "Determining local thermal transport in a composite uranium-nitride/silicide nuclear fuel using square-pulse transient thermoreflectance technique", S. Middlemas, Z. Hua, V. Chauhan, W. T. Yorgason, R. Schley, A. Khanolkar, M. Khafizov, D. Hurley, *J. Nucl. Mater.* **528**, 151842 (2020)
- "Calculated thermodynamic properties of GdCl3 in LiCl-KCl eutectic molten salt", W. Zhou, Y. Wang, J. Zhang, M. Khafizov, *J. Nucl. Mater.* **508**, 40 (2018)
- "Investigation of thermal transport in composites and ion beam irradiated materials for nuclear energy applications", M. Khafizov, V. Chauhan, Y. Wang, F. Riyad, N. Hang, and D. H. Hurley *J. Mater. Res.* **32**, 204 (2017)
- "Microstructure changes and thermal conductivity reduction in $UO_2$ following 3.9 MeV $He^{2+}$ ion irradiation", J. Pakarinen, M. Khafizov, L. He, C. Wetteland, J. Gan, A. T. Nelson, D. H. Hurley, A. El-Azab, T. R. Allen, *J. Nucl. Mater.* **454**, 283 (2014)
- "Transformations and Cracks in Zirconia Films Leading to Breakaway Oxidation of Zircaloy", H. El Kadiri, Z. N. Utegulov, M. Khafizov, M. Asle Zaeem, M. Mamivand, A.L. Oppedal, K. Enakoutsa, M. Cherkaoui, R. G. Graham, A. Arockiasamy, *Acta Materialia* **61,** 3923 (2013)
- "Multiple Exciton Generation in Single-walled Carbon Nanotubes", S. Wang, M. Khafizov, X. Tu, M. Zheng, T. D. Krauss, *Nano Lett*. **20**, 2381 (2010)

## SYNERGISTIC ACTIVITIES

- Manuscript reviewer for *Physical Review Letters, Journal of Applied Physics, Scientific Reports, Journal of American Ceramic Society, Acta Materialia, ACS Nano, International Journal of Thermal Sciences, Thin Films, Journal of Raman Spectroscopy, IEEE Transactions on Nuclear Science, Journal of Nuclear Mateirals* and *Nuclear Instruments and Methods B*.
- Grant reviewer for DOE SBIR, DOE NEUP, and NSF
- Organizer of "Big Data for Nuclear Power Plants" workshop held in Columbus, OH
- Session organizer for 2015 Fall MRS annual meetings: Phonon Transport, Interactions and Manipulations in Nanoscale Materials and Devices—Fundamentals and Applications
- Session organizer for 2017 TMS Annual Meeting: Ceramic Materials for Nuclear Energy Research and Applications
- Session organizer for 2020 TMS Annual Meeting: Thermal Transport in Crystalline and Non-crystalline Solids: Theory and Experiments
- Guest editor for special issues in *Nuclear Technology* and *Progress in Nuclear Energy*

**Dean Wang**

Associate Professor

Nuclear Engineering Program, The Ohio State University

**Education**

• Ph.D. Reactor Physics and Fuel Management Massachusetts Institute of Technology 2003
• M.S. Reactor Engineering and Safety Tsinghua University 1998
• B.S. Nuclear Engineering Harbin Engineering University 1995

**Professional Experience**

• **Associate Professor** *The Ohio State University* 2018–Present

Dr. Wang's research focuses on the development and application of mathematical and computational methods for reactor modeling and simulation with emphasis on neutron transport, fluid dynamics, heat transfer, and multi-physics coupling. Dr. Wang is currently leading a multi-year NASA project on Centrifugal Nuclear Thermal Rocket (CNTR) neutronics research.The notable research work: asymptotic diffusion limit analysis, transport acceleration schemes (lpCMFD, LR-NDA), S*N* numerical methods (LF-WENO, HWENO, and ANDO), and computational two-phase flow.

• **Associate Professor** *University of Massachusetts Lowell* 2014–2018

Dr. Wang led a DOE ENUP project on the development of advanced numerical and acceleration schemes for neutron transport such as the DOE NEAMS neutronics code PROTEUS. Dr. Wang also led a DOE NEUP project on RCIC model development, and a project on advanced FHR design.

• **R&D Staff** *Oak Ridge National Laboratory* 2010–2014

At ORNL, Dr. Wang's research focused on nuclear reactor modeling and simulation, and the development of advanced numerical methods and computational algorithms for reactor analysis. He participated and played an important role in the DOE Fukushima accident emergency response and is a coauthor of the widely cited report of Fukushima Daiichi Accident Study. Dr. Wang and his coauthors also published an influential study on the Fukushima Daiichi unit 4 spent fuel pool.

Dr. Wang and his collaborators published the NRC NUREG report on cross-section generation guidelines for coupled TRACE/PARCS analysis.

Dr. Wang successfully implemented 2nd-order numerical schemes in the NRC's reactor safety analysis code TRACE. His work has solved the long-standing problem of numerical diffusion associated with the widely used 1st-order upwind method for two-phase flow.

He developed a TRACE system analysis model for the advanced high temperature reactor (AHTR), which is a fluoride salt-cooled nuclear reactor design concept.

• **Sr. Scientist** *Information Systems Laboratories, Inc.* 2003–2010

After graduating from MIT, Dr. Wang spent seven and a half years as a senior scientist at the Information Systems Laboratories, Inc., working on reactor safety analysis and code assessment for the U.S. Nuclear Regulatory Commission (NRC).

He was heavily involved in the development and application of TRACE/PARCS models for reactor safety analysis of both existing nuclear power plants and advanced reactor designs such as ABWR, ESBWR, AP1000, US-APWR, etc.

**Publications**

• Z. Zhu, **D. Wang**, V. de Almeida, C. Forsberg, E. Shwageraus, "A Novel Core Design with Movable Moderator for a High Temperature Fluoride Salt-cooled Reactor," *Nuclear Science and Engineering*, 197, 6, 1197 (2023).

• **D. Wang**, "Stability Analysis of Picard Iteration for Coupled Neutronics/Thermal-Hydraulics Simulations," *Trans. Am. Nucl. Soc.*, **128**, 246–249 (2023).

• F. Abdullatif, **D. Wang**, "A Multilevel Quasi-Static Kinetics Module for Monte Carlo Simulations," *Trans. Am. Nucl. Soc.*, **128**, 252–255 (2023).

• F. Abdullatif, **D. Wang**, "Acceleration of Source Convergence in Monte Carlo Criticality Calculation

with CMFD Schemes," *PHYSOR2022*, Pittsburgh, PA, May 15–20, 2022.
• W. Zhang, D. Wang, "Development of the Reactor Core Isolation Cooling System Model for the Extended Station Black-out Accident," *Nuclear Engineering and Design*, 377, (2021).
• **D. Wang**, "Application of lpCMFD for K-Eigenvalue Transport Problems with Feedback," *Trans. Am. Nucl. Soc.*, **123**, 681–684 (2020).
• F. Abdullatif, **D. Wang**, "O-SRS: A Refueling and Shuffling Toolkit for Serpent Core Neutronics Analysis," Trans. AM. Nucl. Soc., 124, ANS Virtual Annual Meeting, June 14–16, 2021.
• C. Forsberg, **D. Wang**, E. Shwageraus, B. Mays, G. Parks, C. Coyle, and M. Liu, "Fluoride-Salt-Cooled High-Temperature Reactor (FHR) Using British Advanced Gas-Cooled Reactor (AGR) Refueling Technology and Decay-Heat Removal Systems that Prevent Salt Freezing," *Nuclear Technology*, 205, 9, 1127 (2019).
• **D. Wang**, S. Xiao, "A Linear Prolongation Approach to Stabilizing CMFD," *Nuclear Science and Engineering*, **190**, 1, 45 (2018).
• **D. Wang**, B. J. Ade, A. M. Ward, "Cross Section Generation Guidelines for TRACE-PARCS," *NUREG/CR-7164*, June 2013.

**Synergistic Activities**

• NASA, "Centrifugal Nuclear Thermal Rocket (CNTR) Neutronics Research at OSU," PI, $1.28m, 2/2023– 1/2028.
• U.S. Department of Energy NEUP Program, "Design of a Commercial-Scale, Fluoride-Salt-Cooled, High-Temperature Reactor with Novel Refueling and Decay Heat Removal Capabilities", PI (previously at UMass Lowell), in collaboration with MIT, U of Cambridge (U.K.), and Framatome, 2017 – 2021.
• U.S. Department of Energy NEUP Program, "Development of a Novel Accelerator for Neutron Transport Solution Using the Galerkin Spectral Element Methods", PI (previously at UMass Lowell), in collaboration with OSU, UM, and ANL, 2015 – 2018.
• Development of the cross section generation guidelines for coupled TRACE/PARCS transient analysis; BWR stability analysis; and development of high resolution numerical methods for TRACE. ORNL, 2010 – 2013.
• Thermal-hydraulic design and analysis of the advanced high-temperature fluoride salt-cooled reactor and technical support for HFIR thermal analysis of irradiation testing and RELAP5 safety analysis. ORNL, 2012 – 2014.

RICHARD VASQUES

Assistant Professor

Department of Mechanical & Aerospace Engineering _

EDUCATION

Ph.D. Applied & Interdisciplinary Mathematics 2009
University of Michigan, Ann Arbor, MI
M.S. Applied Mathematics 2005
Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil
B.S. Applied & Computational Mathematics 2002
Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil

EMPLOYMENT

Assistant Professor, Department of Mechanical & Aerospace Engineering
The Ohio State University, Columbus, OH
Assistant Project Scientist, Department of Nuclear Engineering
University of California, Berkeley, CA
Research Fellow, Department of Mechanical Engineering
Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil
08/2012 - 07/2014 Wissenschaftlicher Mitarbeiter, Center for Computational Engineering Science
RWTH Aachen University, Aachen, Germany
03/2011 - 07/2012 Assistant Professor, Funda_c~ao Getulio Vargas
Escola de Administra_c~ao de Empresas de S~ao Paulo, S~ao Paulo, Brazil
10/2009 - 02/2011 Associate Consultant, McKinsey & Company
S~ao Paulo, Brazil

PUBLICATIONS

J.K. Patel, L.R.C. Moraes, R. Vasques, R.C. Barros. \Transport synthetic acceleration for the solution of the one-speed nonclassical spectral SN equations in slab geometry." Journal of Computational and Applied Mathematics 401: 113768 (2022).

J.J. Kuczek, J.K. Patel, R. Vasques. Modi_ed Fokker-Planck acceleration for forward peaked transport problems in slab geometry." Journal of Computational and Theoretical Transport 50: 430{453 (2021).

R.K. Palmer, R. Vasques. \Asymptotic derivation of the simplified PN equations for nonclassical transport with anisotropic scattering." Journal of Computational and Theoretical Transport 49: 331{348 (2020).

R. Vasques, L.R.C. Moraes, R.C. Barros, R.N. Slaybaugh. \A spectral approach for solving the nonclassical transport equation." Journal of Computational Physics 402: 109078 (2020). doi: 10.1016/j.jcp.2019.109078.

I. Makine, R. Vasques, R.N. Slaybaugh. \Exact transport representations of the classical and nonclassical simpli_ed PN equations." Journal of Computational and Theoretical Transport 47: 326{349 (2018).

R. Vasques, K. Krycki, R.N. Slaybaugh. \Nonclassical particle transport in one-dimensional random periodic media." Nuclear Science and Engineering 185: 78{106 (2017).

M. Wollmann da Silva, R. Vasques, B.E.J. Bodmann, M.T. Vilhena. \A nonsti_ solution for the stochastic neutron point kinetics equations." Annals of Nuclear Energy 97: 47{52 (2016).
R. Vasques. \The nonclassical di_usion approximation to the nonclassical linear Boltzmann equation." Applied Mathematics Letters 53: 63{68 (2016).

M. Frank, K. Krycki, E.W. Larsen, R. Vasques. \The nonclassical Boltzmann equation, and di_usion-based approximations to the Boltzmann equation." SIAM Journal on Applied Mathematics 75: 1329{1345 (2015).

R. Vasques, N.K. Yadav?. \Adjusted Levermore-Pomraning equations for di_usive random systems in slab geometry." Journal of Quantitative Spectroscopy & Radiative Transfer 154: 98{112 (2015).

6. R. Vasques, E.W. Larsen. \Non-classical particle transport with angular-dependent pathlength distributions. II: Application to pebble bed reactor cores." Annals of Nuclear Energy 70: 301{311 (2014).

R. Vasques, E.W. Larsen. \Non-classical particle transport with angular-dependent pathlength distributions. I: Theory." Annals of Nuclear Energy 70: 292{300 (2014).

J4. R. Vasques. \Nuclear energy is renewable energy." Energy Research Journal 5: 33{34 (2014).

E.W. Larsen, R. Vasques. \A generalized linear Boltzmann equation for non-classical particle transport." Journal of Quantitative Spectroscopy & Radiative Transfer 112: 619{631 (2011).

**PRANEETH KANDLAKUNTA**

Research Assistant Professor, Nuclear Engineering Program

**Education and Training:**

| Institution | Major/Area | Degree | Year Completed |
|---|---|---|---|
| Birla Institute of Technology and Science-Pilani, India | Electronics and Instrumentation Engineering | B.E.(Honors) | 2008 |
| The Ohio State University | Nuclear Engineering | M.S. | 2012 |
| The Ohio State University | Nuclear Engineering | Ph.D. | 2014 |
| Washington University in St. Louis – School of Medicine | Medical Physics | Post-doctoral training | 2018 |

**2022 – Present** **Research Assistant Professor, Nuclear Engineering Program, OSU**

Conducting research with focus on nuclear instrumentation and radiation detection applications in nuclear non-proliferation, nuclear industry and healthcare; research on radiation applications in medicine and healthcare; supervising graduate and undergraduate student research.

**2020 – 2022** **Research Associate 2-Engineer, Nuclear Engineering Program, OSU**

**2018 – 2020** **Research Associate 1-Engineer, Nuclear Engineering Program, OSU**

Nuclear instrumentation and radiation detection methods; evaluation of novel neutron and gamma-ray sensors, nuclear voltaic devices, and scintillation materials; Monte Carlo and finite element simulations of radiation interaction with materials. Assisting with proposal preparation; advising graduate and undergraduate students.

**2015 – 2018** **Postdoctoral Research Associate, Department of Radiation Oncology, Washington University in St. Louis – School of Medicine**

Finite element thermal modeling and Monte Carlo (MC) simulations and analysis of X-ray target materials for high-power X-ray sources; hardware and instrumentation for a high-power distributed X-ray source; MC simulations of a gamma-ray detector in proton therapy application; MC modeling and simulations for radiation therapy dose evaluation; supervising undergraduate students on research.

**2013 –2014** **Nuclear Engineer, MP Machinery and Testing, LLC. State College, Pennsylvania.**

Performed neutron transport calculations and analyses using discrete ordinates transport codes for nuclear utility plants.

**2010 –2013** **Graduate Research Associate, Nuclear Engineering Program, OSU**

Proposed and validated a gamma-ray discrimination method for gadolinium-based semiconductor neutron detector using Monte-Carlo simulations and experiments. Developed and characterized a lithium-6 scintillator glass-based neutron beam monitor for OSU Research Reactor’s neutron beam facility. Designed and built a vacuum chamber based digital spectroscopy instrumentation system.

**Courses and Teaching**

- Spring 2024 Instructor for Nuclear Instrumentation, Radiation Sensors and Detection – NUCLREN 5742
- Autumn 2024 Instructor for NUCLREN 5001 Interactions of Radiation with Matter and NUCLREN 5606 Radiation Protection and Shielding

Journal Publications (Selected):

1. Remy J, **Kandlakunta P**, Blue TE, Paranthaman MP, Cao LR. “Demonstrating the β-Ga2O3 Schottky diodes for alpha radiation detection.” *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*. 2024 Oct 1;1067:169686.
2. Panaccione W, Shi Z, **Kandlakunta P**, Nichols T, White S, Huang J, Cao LR. “Testing of an organic metal halide perovskite for fast neutron detection.” *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment.* 2024 Jul 1;1064:169340.
3. **Kandlakunta P**, Van Zile M, White S, Cao LR. “Response of silicon solar cells to neutrons in post-detonation monitoring.” *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment*. 2024 Jun 1;1063:169217.
4. **Kandlakunta P**, Van Zile M, Cao LR. “Silicon Solar Cells for Post-detonation Monitoring and Gamma-Radiation Effects.” *Nuclear Science and Engineering.* 2022 Nov 2;196(11):1383-96.
5. Dai X, Fei C, **Kandlakunta P**, Zhao L, Ni Z, Cao LR, Huang J. “Origin of the X-ray Induced Damage in Perovskite Solar Cells” *IEEE Transactions on Nuclear Science*. 2022 Jul 12;69(8):1850-6.
6. **Kandlakunta P**, Tan C, Smith N, Xue S, Taylor N, Downing RG, Hlinka V, Cao LR. “Silicon carbide detectors for high flux neutron monitoring at near-core locations.” *Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment.* 2020 Feb 11;953:163110.
7. Pan L, Feng Y, **Kandlakunta P**, Huang J, Cao LR. “Performance of Perovskite $CsPbBr_3$ Single Crystal Detector for Gamma-Ray Detection.” *IEEE Transactions on Nuclear Science.* 2020 Jan 7;67(2):443-9.
8. Yang S, Xu Z, Xue S, **Kandlakunta P**, Cao L, Huang J. “Organohalide Lead Perovskites: More Stable than Glass under Gamma-Ray Radiation.” *Advanced Materials*. 2018 Nov 28:1805547.
9. **Kandlakunta P**, Pham R, Khan R, Zhang T. “Development of multi-pixel x-ray source using oxide-coated cathodes” *Physics in Medicine & Biology*, 2017 Jun 13;62(13):N320.
10. **Kandlakunta P**, Cao LR, Mulligan P. “Measurement of internal conversion electrons from Gd neutron capture.” *Nuclear Instruments and Methods in Physics Research Section A*, **705**, 36 (2013).

**Invention Disclosures and Patent Applications**

- Zhang T, **Kandlakunta P**, inventors; Washington University in St Louis WUSTL, assignee. “Multi-pixel x-ray source with tungsten-diamond transmission target.” *United States Patent US 11,289,301. 2022 Mar 29*.
- Cao LR and **Kandlakunta P**, inventors; The Ohio State University “Tritium detection devices and methods of making and use thereof.” Patent application number: 63/355,170
- Cao LR, Co A, **Kandlakunta P**, Hattrick-Simpers J, inventors; The Ohio State University “Devices, systems, and methods for tritium gas detection.” Patent application number: 63/396,908

**Synergistic Activities**

1. Co-chaired the " Nuclear Non-proliferation" session at the 4th Big Data for Nuclear Power Plants Workshop 2023 held in Columbus, Ohio.
2. 2023 Session Chair, "Isotopes and Radiation: General," American Nuclear Society (ANS) Winter Meeting Nov 12-15, 2023, Washington, DC, United States.
3. 2019 Session Chair, " Radiation Detection and Imaging," American Nuclear Society (ANS) Winter Meeting Nov 12-17, 2019, Washington, DC, United States.
4. Reviewer for DOE Phase I&II Release 1&2 SBIR/STTR Proposals and DOE-Consolidated Innovative Nuclear Research NEUP Proposals.
5. Reviewer for IEEE Transactions on Nuclear Science and Nucl. Instr.& Methods (NIM) A Journals

**Taiyang Zhang**
**Assistant Professor**
**Nuclear Engineering, OSU**

**PhD. In Nuclear, Plasma and Radiological Engineering, University of Illinois, August 2023**

**MS in Nuclear, Plasma and Radiological Engineering, University of Illinois, December 2019**

**BS in Nuclear Engineering, University of Science and Technology of China, June 2018**

**Post-doctoral research internship – Argonne National Laboratory , May 2022 to August 2022.**

**Journal Publications**

1. Bottini, J. L., **Zhang, T.,** & Brooks, C. S. (2024). Validation of Two-group Interfacial Area Transport Equation in Boiling Flow. *International Journal of Heat and Mass Transfer*. (*Submitted*)
2. **Zhang, T.**, & Brooks, C. S. (2023). System Code Validation of Periodic Two-phase Flow from Low-pressure Oscillations. *Applied Thermal Engineering*. (*Submitted*)
3. Zhu, L., Ooi, Z. J., **Zhang, T.**, Brooks, C. S., & Pan L. (2023). Identification of flow regimes in boiling flow with clustering algorithms: An interpretable machine-learning perspective. *Applied Thermal Engineering*, 228, 120493.
4. **Zhang, T.**, & Brooks, C. S. (2023). Stability Tests and Analysis of a Low-Pressure Natural Circulation Loop with Flashing Instability. *Nuclear Technology*, 1-28. (**Invited and published**)
5. Zhu, L., **Zhang, T.**, Bottini, J. L., & Brooks, C. S. (2022). Two-dimensional quantitative study of boiling flow evolution in vertical inner-heated annulus channel. *International Journal of Heat and Mass Transfer*, 183, 122190.
6. **Zhang, T.**, Smith, E. R., Brooks, C. S., & Fanning, T. H. (2021). Validation of SAS4A/SASSYS-1 for predicting steady-state single-phase natural circulation. *Nuclear Engineering and Design,* 377, 111149.
7. **Zhang, T.**, & Brooks, C. S. (2021). Linear stability analysis of flashing instability based on the homogeneous equilibrium model. *Nuclear Engineering and Design*, 373, 110994.
8. Ooi, Z. J., **Zhang, T.**, & Brooks, C. S. (2020). Experimental dataset with high-speed visualization for vertical upward steam-water flow with transition from annulus to circular channel. *International Journal of Heat and Mass Transfer*, 161, 120281.
9. **Zhang, T.,** Ooi, Z. J., Skrzypek, M., & Brooks, C. S. (2020). A multi-dimensional dataset for two-phase instability in low pressure natural circulation based on direct transient local measurement. *International Journal of Heat and Mass Transfer*, 151, 119447.

10. Bottini, J. L., Zhu, L., Ooi, Z. J., **Zhang, T.,** & Brooks, C. S. (2020). Experimental study of boiling flow in a vertical heated annulus with local two-phase measurements and visualization. *International Journal of Heat and Mass Transfer*, 155, 119712.
11. **Zhang, T.**, & Chen, R. (2017). A collisional-radiative model for lithium impurity in plasma boundary region of Experimental Advanced Superconducting Tokamak. *Acta Physica Sinica*, 66(12), 125201.

**Thomas E. Blue. Ph.D.**

**Contact Information:** Academy Professor, Nuclear Engineering Program, Department of Mechanical and Aerospace Engineering, The Ohio State University, 201 W. 19th Street, Columbus, OH; Phone: (614) 292-0629; Fax: (614) 292-3163; E-mail: Blue.1@osu.edu

**Education and Training:**

| | | | |
|---|---|---|---|
| Miami University | Oxford, OH | Physics | B.S., 1972 |
| University of Michigan | Ann Arbor, MI | Nuclear Science | M.S., 1973 |
| University of Michigan | Ann Arbor, MI | Nuclear Engineering | Ph.D., 1978 |

**Research and Professional Experience:**

| | |
|---|---|
| 2016-present | Academy Professor, The Ohio State University |
| 2007-2016 | Director, Nuclear Reactor Laboratory, The Ohio State University |
| 1997-2016 | Full Professor, Dept. of Mech. & Aerospace Engr., Ohio State Univ. |
| 1990-1997 | Assoc. Professor, Dept. of Mech. & Aerospace Engr., Ohio State Univ. |
| 1984-1990 | Asst. Professor, Dept. of Mech. & Aerospace Engr., Ohio State Univ. |
| 1978-1984 | Asst. Professor, Nuclear Engineering, University of Illinois |
| 1977 | Consultant, KMS Fusion, Ann Arbor, MI |
| 1975-1977 | Research Assistant in Nuclear Engineering, University of Michigan |
| 1973-1975 | Scientist, LWBR Design and Operations, Bettis Atomic Power Lab |

**Honors and Awards:**

1. Elected Fellow of the American Nuclear Society, April 2002
2. Received 2012 Lumley Interdisciplinary Research Award from Ohio State University, College of Engineering.

**Publications: (from over 116 archival journal publications and over 217 refereed proceedings)**

1. "In-situ gamma radiation-induced attenuation in sapphire optical fibers heated to 1000$^{o}$C." C. Petrie, B. Wilson, T.E. Blue. J. Am. Ceram. Soc., 97(10): 3150–3156; (2014).
2. "In-situ thermally-induced attenuation in sapphire optical fibers heated to 1400$^{o}$." C. Petrie, T.E. Blue. J. Am. Ceram. Soc. 98(2):483-489. February 2015.
3. "In-situ reactor radiation-induced attenuation in sapphire optical fibers heated up to 1000 $^{o}$C." C. Petrie and T.E. Blue. Nuclear Inst. and Methods in Physics Research, B, 342: 91-97; (Jan. 2015.)
4. "In-situ reactor radiation-induced attenuation in sapphire optical fibers." C. Petrie, W. Windl, T.E. Blue. J. Am. Ceram. Soc. 97(12): 3883-3889; December 2014.
5. "Reactor Radiation-Induced Attenuation in Fused Silica Optical Fibers Heated up to 1000°C." C. Petrie, D. Hawn, W. Windl, T.E. Blue. J. of Non-Crystalline Solids 409: 88-94 (Feb 1, 2015).
6. "An Analytical Model for the Time Constants of Optical Fiber Temperature Sensing." R.K. Palmer, K.M. McCary, and T.E. Blue. IEEE Sensors Journal, 17(17):5492-5502. September 1, 2017.
7. "Effect of gamma-ray and neutron heating as interfering input for the measurement of temperature using optical fiber sensor system." T.E. Blue, B. Wilson. IEEE Transactions on Nuc. Sci. 64(11):2774-

2781. Nov. 2017.

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10. "High-Temperature Effects on the Light Transmission through Sapphire Optical Fiber." B. A. Wilson, C. M. Petrie, T.E. Blue. J. Am. Ceram. Soc. 101:3452-3459. June 4, 2018.
11. "Thermally Induced Bend Loss of Silica Optical Fiber." A. Birri, K. McCary, B.A. Wilson, T.E. Blue. IEEE Sensors Journal. 18(15): 6181-6187, 2018.
12. "Quasi-distributed Temperature Sensing using Type-II Fiber Bragg Gratings in Sapphire Optical Fiber to Temperatures up to 1300$^{o}$C." B. Wilson and T.E. Blue. IEEE Sensors, 18(20):8345-8351. Oct.2018.
13. "Modeling the creation of an internal cladding in sapphire optical fiber using the $^{6}Li(n,\alpha)^{3}H$ reaction." B. Wilson, S. Rana, H. Subbaraman, N. Kandadai, T.E. Blue. IEEE/OSA Journal of Lightwave Technology, 36(23): 5381-5387. December 1, 2018.
14. "Deduced Refractive Index Profile Changes of Type I and Type II Gratings when Subjected to Ionizing Radiation." A. Birri, B. Wilson, T.E.Blue. IEEE Sensors, 19(13):5000-5006, July 1, 2019.
15. "High-dose temperature-dependent neutron irradiation effects on the optical transmission and dimensional stability of amorphous fused silica." C. Petrie, A. Birri, T.E. Blue. Journal of Non-Crystalline Solids 525 (2019).
16. "Analytic Thermal Model of an Optical Fiber Based Gamma Thermometer and its Application in a University Research Reactor." A. Birri, C. Petrie, T.E. Blue. IEEE Sensors Journal, 20(13):7060-7068. July 1, 2020.

**Interests:**

My present interests are advanced nuclear reactor instrumentation, including fiber optics and semiconductor sensors, static and dynamic characterization of radiation-induced degradation of optical fiber and semiconductor power devices (especially at high temperatures) and space nuclear systems. I am especially interested in continuing to work on projects that advance the technology that is included in these patents (for which I am the Primary Inventor):1) US Patent: INTERNAL CLADDING IN SAPPHIRE OPTICAL DEVICE AND METHOD OF MAKING SAME; Patent No.:US 10,436,978; Date of Patent: Oct. 8, 2019 and 2) US Patent: OPTICAL FIBER-BASED GAMMA CALORIMETER (OFBGC); Docket Number10336-768US1; Filing Date: May 5, 2020.

# Richard S. Denning

**Emeritus Professor of Nuclear Engineering, The Ohio State University**

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**Education**

B.E., Physics, Cornell University (1963)
M.S.E., Nuclear Engineering, University of Florida (1965)
Ph.D., Nuclear Engineering, University of Florida (1967)

**Positions**

1996-Current, Private Research Consultant

2022-Current, Emeritus Professor, The Ohio State University, Nuclear Engineering Program

1999-2014, The Ohio State University, Nuclear Engineering Program

Adjunct Professor, Program Chair from 1999-2001; April 2006-June 2007.

September 2004-August 2006, NRC Advisory Committee on Reactor Safeguards -Committee member

1987-1991 DOE Advisory Committee on Nuclear Facility Safety

Committee member.

1967-2009 Battelle Memorial Institute

Held technical positions from Principal Research Scientist to Sr. Research Leader.

**Research Experience**

Dr. Denning is an internationally recognized expert in the fields of risk analysis, nuclear analysis, nuclear safety, and severe accident behavior of nuclear reactors. He began his career at Battelle Memorial Institute where he managed studies of the safety and risk of a variety of nuclear facilities including commercial nuclear power plants and a number of DOE's non-reactor nuclear facilities. He was responsible for the development of Level II methods of Probabilistic Risk Assessment for the WASH-1400 study. He assisted the NRC in the development and oversight of its severe accident research program. He was a consultant to the TMI Special Inquiry Group. He also managed the analysis of severe accident progression and source terms for the five reference plants in the NRC's reexamination of the risk of light water reactors, NUREG-1150. He authored two chapters of the PRA Procedures Guide, NUREG/CR-2300. He was a member of DOE's Advisory Committee on Nuclear Facility Safety 1987-1991. From 1990-1992 he was the Director of Environment, Safety and Health for the multi-organization consortium that designed the heavy water new production reactor. From 1995 to 2007, he had responsibility for the oversight of safety hardware upgrades in DOE's program to improve the safety of former Soviet Union reactors (PNNL was the DOE lead laboratory). Dr. Denning served on the independent review and advisory committee for the No-Action Alternative Analysis for the Yucca Mountain Environmental Impact Statement in 1998-1999. In 2002 and 2003, he chaired a team of DOE laboratory scientists and university professors that prepared "Guidelines for the Performance of Non-Proliferation Assessments" for DOE-NNSA. He was a member of the NRC's Advisory Committee on Reactor Safeguards from September 2004 to August 2006.

He chaired the Nuclear Engineering Program at The Ohio State University from July 1999 to June 2001 and from March 2006 to June 2007. While at OSU, he advised students and performed research in the field of dynamic probabilistic risk assessment. He is currently an Emeritus Professor of Nuclear Engineering.

In 2011, he participated on a peer review committee for the NRC's planned revisions to the Alternative Source Term for severe accidents in light water reactors to account for higher burnup and mixed oxide fuels. In 2023, he participated on a subsequent peer review committee for severe accident source terms for advanced fuels and high burnup fuels for the NRC. In 2010 and 2011, in support of a DOE assessment of the status of Sodium Cooled Fast Reactor Technology he served on two technical committees: one assessing the capability for the analysis of accident scenarios and the second reviewing the capability for assessing severe accident source terms.

He was a co-PI on four DOE-NEUP projects, one examining the use of dynamic approaches to the analysis of proliferation in collaboration with BNL, the development of the mechanistic treatment of plant aging processes in probabilistic risk assessment in collaboration with PNNL, a sodium-cooled fast reactor risk study performed in collaboration with MIT, and the development of mechanistic approaches to the assessment of seismic risk in collaboration with the Civil Engineering Department of OSU.

**Recent Consulting Activities:** Phenomena Identification and Ranking Table for Natrium Sodium Cooled Fast Reactor (TerraPower); Phenomena Identification and Ranking Table of Molten Salt Reactors (ORNL); Seminar on licensing issues associated with micro-reactors within the INL Fission Battery initiative. Treatment of External Events for Non-Light Water Reactors (ANL); Phenomena Identification and Ranking Table for Accident Tolerant Fuels (ERI/NRC (2011 and 2023); Development of a Semi-Autonomous Supervisory Control System for Advanced Reactors (ORNL); Phenomena Important in the Modeling and Simulation of Molten Salt Reactor Accidents (BNL/NRC); Assessment of DOE Sodium Fast Reactor Gap Analysis, Accident Sequence and Source Term Committees (Sandia National Laboratory); Sodium Reactor Experiment Technical Review (SNL); Post-Fukushima Activities (Exelon); Revision to NRC's Alternative Source Term (Energy Research, Inc); New Source Term for ATR (Polestar and MPR Assoc.); AP-1000 Seismic Design Review (proprietary); Development of methods for Performing Seismic Probabilistic Risk Assessment (OSU, NEUP); Advanced Liquid Metal Source Term Sensitivity Study and Research Prioritization (ANL).

**Example Publications.**


- Hakobyan, T. Aldemir, R. Denning, B. Rutt, U. V. Catalyurek, S. Dunagan and D. Kunsman, "Dynamic Generation of Accident Progression Event Trees", Nuclear Engineering and Design, 238, 3457 – 3467 (2008).
- Brunett, R. Denning, T. Aldemir, "Application of Limit Curves to the Risk-Informed Regulation of SFRs," *Transactions of the American Nuclear Society*, June 2009.
- R. Denning, A. Brunett, D. Grabaskas, M. Umbel, and T. Aldemir, "Toward More Realistic Source Terms for Metallic-Fueled Sodium Fast Reactors," ICAPP, June 2010.
- Johnson, B. C., G. E. Apostolakis and R. Denning, "Application of a Limit Exceedance Importance Measure to Risk-Informed Design," Nuclear Technology, V. 172, pp 108-119, 2010.
- R. Denning and V. Mubayi, "Insights Into the Societal Risk of Nuclear Power Plant Accidents," Journal of Risk Analysis, February 2016.

- R.S. Denning and R. J. Budnitz, "Impact of Probabilistic Risk Assessment and Severe Accident Research in Reducing Reactor Risk," Progress in Nuclear Energy, Vol. 102, January 2018.
- R. Denning, D. Grabaskas, and M. Bucknor, "Severe Accident Source Terms for Small Modular SFRs," Probabilistic Safety Analysis, 2019, November 2019.
- D. E. Holcomb, A. J. Huning, M. D. Muhlheim, R. S. Denning, G. F. Flanagan, "Molten Salt Reactor Fundamental Safety Function PIRT," ORNL/TM-2021/2176, September 2021.
- R. Denning, "Satisfying a Risk Limit Curve," Probabilistic Safety Analysis 2021, November 2022.

**Honors and Awards:** ANS Fellow, International Nuclear Societies Global Award 2014**.**

## Appendix F Alignment of Courses with ABET Requirements

This appendix summarizes the curriculum course mapping to meet the basic math and science, engineering topics, design culmination and specific nuclear engineering course related requirements defined by ABET general criteria to satisfy a Baccalaureate Level Program in Nuclear Engineering.

### Overall Curriculum Course Mapping for ABET Requirements for Undergraduate Degree in Nuclear Engineering

The program must include the following curricular topics in sufficient depth for engineering practice to support analyses of complex nuclear or radiological problems,
(a) mathematics
(b) atomic and nuclear physics,
(c) transport and interaction of radiation with matter,
(d) nuclear or radiological systems and processes,
(e) nuclear fuel cycles,
(f) nuclear radiation detection and measurement,
(g) nuclear or radiological system design.

Table 1: Proposed NE curriculum in meeting general mathematics, fundamentals of engineering and design, and NE subject matter as specified by ABET.

| Course(s) | ABET Basic and Specific Curriculum Requirement | | | | | | |
|---|---|---|---|---|---|---|---|
| | a | b | c | d | e | f | g |
| Mathematics and Basic Science Requirements (Current subjects Math 1151, 1172, 2173, 2174, Physics 1250 and 1251, General Chemistry 1250 and General Education) Total 36 credits including 6 credits of General Education; **Meets 30 hours of course requirement for Mathematics and Basic Sciences from ABET course related requirement** | M | M | | | | | |
| Engineering Topics Requirements (ENGR 1181 and 1182, ENGR 1100, NUCLENG Survey, MECHENG 2850, MECHENG 2040, MATSCEN 2010, ECE 2300, ME3500, NE3260, NUCLENG Radiation Detection, NE Reactor Systems, NE Reactor Operations, NE Health Physics, NE Thermal Hydraulics, NE Lab course) Total 52 credits including 6 credits of General Education; **Meets 45 hours course requirement for Mathematics and Basic Sciences from ABET course related requirement** | M | M | L | L | L | L | L |
| NUCLENG 4505, Introduction to Nuclear Science and Engineering | M | H | M | M | L | M | L |
| NUCLENG 4520, Radiation Detection | M | H | H | M | X | H | M |
| NUCLENG 4506, Radiation Detection Laboratory | M | M | H | H | X | H | M |
| NUCLENG 4536, Thermal Hydraulics and Engineering Design | H | M | L | M | M | L | M |
| NUCLENG 4570, Health Physics | M | H | H | M | L | M | M |
| NUCLENG 4570, Reactor Physics | H | M | M | M | L | L | M |
| NUCLENG 4530, Nuclear Power Plant Operations | H | H | M | M | M | L | H |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Design Requirement (NUCLENG 4580 and 4581, Capstone Design I & II | H | H | H | H | H | H | H |

**Acronyms:**

**H: High Impact, M: Medium Impact, L: Low Impact, X: No Impact**

**<u>Comment:</u>** Please make a note that in above table of courses, NE elective courses have not been included and/or have not been depicted to satisfy the ABET requirements to establish a Baccalaureate Level Program in Nuclear Engineering.

**ABET related Specific Curriculum requirements and student outcomes**: This part of document depicts nuclear engineering specific courses in the table satisfying the program related criteria apply to engineering program that include nuclear, radiological and similarly named engineering programs. The table mentioned below identifies courses and sufficient depth of topics covered in proposed courses at Baccalaureate Level Program of Nuclear Engineering for evaluating the ABET related student outcomes.

**Student Outcome Performance Assessment Method at OSU**

In context to measure the student outcomes in NE Program, conventional assessment techniques (i.e., Midterm Exams, Homework Assignments, Quizzes, Semester Project, and Lab Reports) will be used to measure the performance of student outcomes. This performance assessment method will be utilized to evaluate ABET related Student Outcome requirements for both basic and specific curriculum courses from above mentioned tables.

***Definition of ABET Criterion 3.***

***Student Outcomes***

The program must have documented student outcomes that support the program educational objectives. Attainment of these outcomes prepares graduates to enter the professional practice of engineering. Student outcomes are outcomes (1) through (7), plus any additional outcomes that may be articulated by the program.

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

3. an ability to communicate effectively with a range of audiences

4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies.

## Appendix G. Course Syllabi

Syllabi for required courses are provided as attached.