

# Department of Chemical and Biomedical Engineering

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E-mail: Statler-CHE@mail.wvu.edu

## Degrees Offered

- Bachelor of Science in Biomedical Engineering (B.S.Bm.E.)
- Bachelor of Science in Chemical Engineering (B.S.Ch.E.)

## Nature of Programs

The Department of Chemical Engineering offers undergraduate degrees in chemical engineering (ChE) and biomedical engineering (BMEG). Chemical engineers focus on processes that convert raw materials such as crude oil, biomass, coal and natural gas into value-added finished products such as plastics, paints, detergents and pharmaceuticals. Biomedical engineers are trained to work at the interface of engineering and biomedical sciences, and they focus on developing engineering skills and applying them to materials, processes and procedures used in medicine and biology. Both degree programs require a strong background in chemistry, mathematics, and physics.

The chemical engineering curriculum is relatively structured with courses that must be taken in a specific sequence. A unique aspect of the ChE curriculum is its heavy emphasis on design, beginning in the sophomore year. Graduates with a BSChE degree are prepared for positions in production, product and process development, sales and marketing, management and also research. There is a large concentration of chemical industry in the area, and the ChE program benefits from interactions with industrial practitioners.

The biomedical engineering program offers significant flexibility of study through a variety of electives. With the participation of faculty from several engineering departments, students learn about cells and tissues but also topics such as imaging and mechanics. Students are encouraged to do research and work side-by-side with faculty in both engineering and the WVU Health Sciences Center in areas such as tissue engineering and cancer diagnosis. Graduates with a BSBmE degree are prepared for solving the health-related problems and improving the quality of life of the aging population within the state and the nation.

Students in both programs are also prepared for graduate school in engineering and for professional schools in business, law and medicine.

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## FACULTY

### CHAIR

- Rakesh Gupta - Ph.D. (University of Delaware)  
Berry Professor and Chair, Professor. Polymer processing, Rheology, Non-Newtonian fluid mechanics, Composite materials

### PROFESSORS

- Brian J. Anderson - Ph.D. (Massachusetts Institute of Technology)  
Director, Energy Institute; GE Materials Professor. Natural gas hydrates, Sustainable energy development, Molecular dynamics, Quantum chemical calculations
- Eugene V. Cilento - Ph.D. (University of Cincinnati)  
Glen H Hiner Dean. Physiological transport phenomena, Biomedical engineering, Image analysis, Mathematical modeling
- Pradeep Fulay - Ph.D. (University of Arizona)  
Associate Dean for Research. Advanced electronics, Magnetic materials and devices, Flexible electronics, Synthesis and processing of nanomaterials
- John (Jianli) Hu - Ph.D. (Tsinghua University)  
Shale gas utilization, Catalysis in refining processes, Coal and biomass conversion
- Richard Turton - Ph.D. (Oregon State University)  
Bolton Professor. P.E. Fluidization, Heat transfer, Particle and powder technology, Chemical process design
- John W. Zondlo - Ph.D. (Carnegie Mellon University)  
Coal enhancement and utilization, Carbon science, Environmental remediation

### ASSOCIATE PROFESSORS

- Debangsu Bhattacharyya - Ph.D. (Clarkson University)  
Integrated gasification combined cycle (IGCC), Chemical looping, Fuel cells (SOFC & PEM), Optimization, Dynamic modeling of process systems, Process control
- Zoica Cerasela Dinu - Ph.D. (Max Planck Inst of Molecular Cell Biology & Genetics & Dresden University of Technology)

Associate Chair, BMEG. Nanomaterials, Bionanotechnology, Biomimetics

- David J. Klinke - Ph.D. (Northwestern University)  
Systems biology, Kinetics, Cellular signal transduction pathways, Immunology, Mathematical modeling, Bioengineering
- Charter D. Stinespring - Ph.D. (West Virginia University)  
Wide bandgap semiconductor growth and etching, Surface kinetics, Thin films, Electronic materials

## ASSISTANT PROFESSORS

- Ahmed E. Ismail - Ph.D. (Massachusetts Institute of Technology)  
Biomass and biopolymers, Interfacial phenomena, Multi-scale modeling, Algorithm development
- Fernando V. Lima - Ph.D. (Tufts University)  
Process design and operability, Model-based control and optimization, State estimation and process identification, Emerging energy systems, and Sustainable processes
- Jeevan Maddala - Ph.D. (Texas Tech University)  
Microfluidics, Cell screening, Nanomaterial synthesis
- Hanjing Tian - Ph.D. (Lehigh University)  
Chemical looping combustion, CO<sub>2</sub> capture, Shale gas utilization, Biomass gasification and refinery
- Yong Yang - Ph.D. (The Ohio State University)  
Stem cell technology, Polymer micro/nanotechnology, Biomaterials

## RESEARCH ASSOCIATE

- Sushant Agarwal - Ph.D. (West Virginia University)  
Polymer processing and characterization, Rheology, Nanocomposites, Emulsions, Nanofluids, Suspensions

## TEACHING ASSISTANT PROFESSOR

- Robin S Hissam - Ph.D. (University of Delaware)  
Biomaterials, Polypeptides, Drug delivery, Bioengineering and materials science

## ADJUNCT PROFESSORS

- Deepak Doraiswamy - Ph.D. (University of Delaware)
- Joseph D. Henry - Ph.D. (University of Michigan)
- Charles M. Jaffee - Ph.D. (University of Colorado)  
Theoretical Chemistry, Molecular and Atomic Physics, Nonlinear Dynamics, Astrodynamics
- George E. Keller, II - Ph.D. (Pennsylvania State University)
- Mahesh Padmanabhan - Ph.D. (University of Minnesota)
- David L. Walker - Ph.D. (West Virginia University)
- Robert Wildi - B.S. (Fenn College/Cleveland State University)
- Stephen Zitney - Ph.D. (University of Illinois at Urbana-Champaign)  
Dynamics, Control and optimization of energy systems; Computational fluid dynamics (CFD) and process co-simulation; Pulverized coal combustion; Oxy-coal Combustion; Integrated gasification combined cycle (IGCC); Chemical looping; Supercritical CO<sub>2</sub> power cycles; CO<sub>2</sub> capture

## ADJUNCT ASSOCIATE PROFESSOR

- Bingyun Li - Ph.D. (Chinese Academy of Sciences)  
Assoc. Prof. of Orthopedics. Bioengineering and advanced biomedical devices, Nanotechnology sorbents, Coatings and capsules

## PROFESSORS EMERITUS

- Eung H. Cho - Ph.D. (University of Utah)  
Mineral processing, Leaching, Solvent extraction, Environmental science
- Dady B. Dadyburjor - Ph.D. (Delaware)  
Catalysis, Reaction Engineering
- Edwin L. Kugler - Ph.D. (Johns Hopkins)  
Catalysis, Adsorption, Coal Liquefaction
- Joseph A. Shaeiwitz - Ph.D. (Carnegie-Mellon)  
Design, Design Education, Outcomes Assessment
- Alfred H. Stiller - Ph.D. (University of Cincinnati)  
Physical/inorganic/solution chemistry, Coal liquefaction, Carbon science
- Ray Y. K. Yang - Ph.D. (Princeton)  
Biochemical and Chemical Engineering, Nonlinear Dynamics

## RESEARCH ASSISTANT PROFESSOR

- Nagasaree Garapati - Ph.D. (West Virginia University)  
Carbon dioxide capture and storage (CCS) in various geologic media, utilizing carbon dioxide in gas hydrate reservoirs, petroleum reservoirs and geothermal reservoirs for enhanced gas, oil and heat recovery
- Huali Wang - Ph.D. (Wayne State University)  
Shale gas, renewable energy, clean energy, energy catalysis, and reaction engineering

## BIOMEDICAL ENGINEERING MINOR

### MINOR CODE - U142

The minor is open to all students with the prerequisite coursework, which includes:

Biology: BIOL 115 OR (BIOL 101, BIOL 102, BIOL 103, AND BIOL 104)

Mathematics: MATH 155 and MATH 156. Students must also complete MATH 251 and MATH 261 for completion of minor.

Chemistry: CHEM 115 and CHEM 116

The minor consists of 5-6 courses, totaling 16 hours.

#### Required Courses:

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BMEG 201	Introduction to Biomedical Engineering
or EE 425	Bioengineering

Choose one of the following:

BIOL 235 & BIOL 236	Human Physiology and Human Physiology: Quantitative Laboratory
BIOL 117	Introductory Physiology

#### Electives:

9

Choose three of the following:

BMEG 310	Biomedical Imaging
BMEG 311	Biomaterials
BMEG 340 or MAE 473	Biomechanics Bioengineering
BMEG 480	Cellular Machinery
BMEG 481	Applied Bio-Molecular Modeling
BMEG 482	Introduction to Tissue Engineering

Total Hours

16

## CHEMICAL ENGINEERING MINOR

### MINOR CODE - U101

Any student may take a minor in chemical engineering by passing the following courses and maintaining a 2.0 GPA or better in these courses.

Courses must be taken in the following order:

CHE 201	Material and Energy Balances 1	3
CHE 202	Material and Energy Balances 2	3
CHE 320	Chemical Engineering Thermodynamics	3
CHE 312	Separation Processes	3
CHE 325	Chemical Reaction Engineering	3

Total Hours

15

## Biomedical Engineering Certificate offered in Chemical Engineering

### CERTIFICATE CODE - CU02

The Department of Chemical Engineering administers a certificate program in biomedical engineering that is open to all students with appropriate prerequisites, which are: basic biology (BIOL 115), mathematics through MATH 261 (differential equations), CHEM 115, and CHEM 116 and a working knowledge of organic chemistry, specifically the naming conventions for, and knowledge of charge distribution in, organic molecules. Currently, the

certificate program consists of six required courses listed below. As other courses are added in the biomedical engineering area, more choices of elective courses will be made available.

#### Required Courses

BIOL 235	Human Physiology	3
BIOL 236	Human Physiology: Quantitative Laboratory	1
BMEG 201	Introduction to Biomedical Engineering	3
BMEG 311	Biomaterials	3
Electives		
BMEG 481	Applied Bio-Molecular Modeling	3
BMEG 482	Introduction to Tissue Engineering	3
Total Hours		16

For chemical engineering undergraduates, the certificate program can be completed with the addition of one additional credit hour (134 hours total). Students wishing to attend medical school will have to take CHEM 234/CHEM 236 (four hours) for a total of 138 credit hours.

#### CHE 102. Introduction to Chemical Engineering. 3 Hours.

PR: ENGR 101 and PR or CONC: (CHEM 116 or CHEM 118.) Overview of traditional and emerging areas of chemical engineering, projects involving computational and programming tools, design projects, written and oral presentation of results, discussions of professional and ethical behavior relating to the engineering professions.

#### CHE 201. Material and Energy Balances 1. 3 Hours.

PR: MATH 155 and CHEM 116 and PR or CONC: ENGR 102 or CHE 102. Introduction to chemical engineering fundamentals and calculation procedures, industrial stoichiometry, real gases and vapor-liquid equilibrium, heat capacities and enthalpies, and unsteady material balances and energy balances. (2 hr. lec., 2 hr. calc. lab.).

#### CHE 202. Material and Energy Balances 2. 3 Hours.

PR: (CHE 201 or CHE 211) and PR or CONC: CHE 230. Continuation of CHE 201. (2 hr. lec., 2 hr. calc. lab.).

#### CHE 230. Numerical Methods for Chemical Engineering. 3 Hours.

PR: (ENGR 102 or CHE 102) and MATH 156 and PR or CONC: (CHE 202 or CHE 212) and MATH 251. Numerical solution of algebraic and differential equations with emphasis on process material and energy balances. Statistical methods optimization, and numerical analysis. (2 hr. lec., 2 hr. calc. lab.).

#### CHE 293. Special Topics. 1-6 Hours.

PR: Consent. Investigation of topics not covered in regularly scheduled courses.

#### CHE 310. Process Fluid Mechanics. 3 Hours.

PR: MATH 251 and (CHE 202 or CHE 212). Fluid statics, laminar and turbulent flow, mechanical energy balance, Bernoulli equation, force balance, friction, flow in pipes, pumps, metering and transportation of fluids, flow through packed beds and fluidized beds. Laboratory demonstrations and experiments. (2 hr. lec., 2 hr. calc. lab.).

#### CHE 311. Process Heat Transfer. 3 Hours.

PR: MATH 251 and (CHE 202 or CHE 212). Conductive heat transfer, convective heat transfer, design and selection of heat exchange equipment, evaporation, and radiation. Applications, laboratory demonstrations, and experiments. (2 hr. lec., 2 hr. calc. lab.).

#### CHE 312. Separation Processes. 3 Hours.

PR: CHE 310 and CHE 311 and CHE 320. Equilibrium stage and multiple stage operations, differential countercurrent contacting, membrane separations, fluid-particle separations.

#### CHE 315. Chemical Engineering Transport Analysis. 3 Hours.

PR: CHE 310 and CHE 311 and CHE 320 and MATH 261. Development of fundamental relationships for momentum, heat and mass transfer for flow systems to include chemical reactions, interphase transport, and transient phenomena. Development and use of microscopic and macroscopic balance equations.

#### CHE 320. Chemical Engineering Thermodynamics. 3 Hours.

PR: (CHE 202 or CHE 212) and MATH 251. First and second laws of thermodynamics. Thermodynamic functions for real materials. Physical equilibrium concepts and applications. (2 hr. lec., 2 hr. calc. lab.).

#### CHE 325. Chemical Reaction Engineering. 3 Hours.

PR or CONC: CHE 312 or CHE 317. Application of material balances, energy balances, chemical equilibrium relations, and chemical kinetic expressions to the design of chemical reactors. (3 hr. lec.).

#### CHE 326. Reaction Phenomena. 3 Hours.

PR: CHE 320 and PR or CONC: CHE 325. Theory and application of reaction kinetics, analysis of rate data, reaction equilibrium, and catalysis. The application of these phenomena to industrial relevant systems will be emphasized.

**CHE 351. Chemical Process Laboratory. 2 Hours.**

PR or CONC: CHE 310 and CHE 311. Reinforcement of practical concepts acquired during the junior year chemical engineering courses on fluids and heat transfer through experimental design and practice.

**CHE 355. Process Simulation and Design. 2 Hours.**

PR or CONC: CHE 312 and CHE 325. The application and use of chemical process simulation software to the design of a chemical process.

**CHE 366. Materials Science. 3 Hours.**

PR: CHEM 116 and junior standing in engineering and mineral resources or chemistry. Chemical bonding and structures of metals, ceramics, and organic materials; the dependence of properties upon these structures and bonding conditions; thermal and mechanical stresses; corrosion; synthesis and preparation of materials.

**CHE 414. Coal Conversion Engineering. 3 Hours.**

PR: CHEM 233 and PR or CONC: (CHE 312 or CHE 317) and CHE 325. Coal conversion processes from the unit-operations approach; thermodynamics, kinetics, and evaluation of system requirements and performance. (3 hr. lec.).

**CHE 435. Chemical Process Control. 3 Hours.**

PR: (CHE 230 or CHE 330) and (CHE 325 or CHE 327). Transient behavior of chemical process flow systems, linearization and stability. Process control system design including frequency response analysis. Instrumentation and hardware.

**CHE 450. Unit Operations Laboratory 1. 2 Hours.**

PR: (CHE 312 or CHE 317) and (CHE 350 or CHE 351). Operation of chemical process engineering equipment; collection, analysis, and evaluation of laboratory report preparation. (4 hr. lab.).

**CHE 451. Unit Operations Laboratory 2. 2 Hours.**

PR: CHE 450. Continuation of CHE 450. (4 hr. lab.).

**CHE 455. Chemical Process Design 1. 4 Hours.**

PR: (CHE 312 or CHE 317) and CHE 325. Analysis, synthesis, and design of chemical process systems. Engineering economics, safety, professional aspects of the practice of chemical engineering. Includes a group chemical plant design project, as well as individual design projects. (3 hr. lec., 4 hr. des. lab.).

**CHE 456. Chemical Process Design 2. 3 Hours.**

PR: CHE 455. Continuation of CHE 455.

**CHE 461. Polymer Science and Engineering. 3 Hours.**

PR: CHEM 233. Polymer classification, polymer synthesis, molecular weights and experimental techniques, thermodynamics, rubber elasticity, mechanical behavior, crystallization, diffusion, rheology, extrusion and injection molding. (3 hr. lec.).

**CHE 462. Polymer Processing. 3 Hours.**

PR: Junior standing in engineering and mineral resources. Flow behavior in idealized situations; extrusion; calendaring; coating; injection molding; fiber spinning; film blowing; mixing; heat and mass transfer; flow instabilities. (3 hr. lec.).

**CHE 463. Polymer Composites Processing. 3 Hours.**

PR: Junior standing in engineering and mineral resources. Advantages and applications of polymer composites; chemistry and kinetics of thermosetting polymers; hand layup and spray up; compression molding; resin transfer molding; reaction injection molding; filament winding; pultrusion. (3 hr. lec.).

**CHE 466. Electronic Materials Processing. 3 Hours.**

PR: Junior standing in engineering and mineral resources. The design and application of thermal, plasma, and ion assisted processing methodologies; solid state, gas phase, surface, and plasma chemistry underpinnings; thin film nucleation and growth; the effect of processing methods and conditions on mechanical, electrical, and optical properties. (3 hr. lec.).

**CHE 471. Biochemical Engineering. 3 Hours.**

PR: CHE 325. Kinetics of enzymatic and microbial reactions, interactions between biochemical reactions and transport phenomena, analysis and design of bioreactors, enzyme technology, cell cultures, bioprocess engineering. (3 hr. lec.).

**CHE 472. Biochemical Separations. 3 Hours.**

PR or CONC: CHE 312 or CHE 317. Modeling and design of separation processes applicable to recovery of biological products. Topics include filtration, centrifugation, extraction, adsorption, chromatography, electrophoresis, membranes, crystallization, and examples from industry. (3 hr. lec.).

**CHE 475. Chemical Process Safety. 3 Hours.**

PR: CHE 202 or CHE 212. Introduction to safety, health and loss prevention in the chemical process industry; regulations, toxicology, hazard identification, system safety analysis and safety design techniques. (3 hr. lec.).

**CHE 476. Pollution Prevention. 3 Hours.**

PR or CONC: (CHE 312 or CHE 317) and CHE 325 and CHE 326. Environmental risk and regulations; fate and persistence of chemicals; green chemistry; evaluation and improvement of pollution performance during chemical process design; life cycle analysis; industrial ecology.

**CHE 490. Teaching Practicum. 1-3 Hours.**

PR: Consent. Teaching practice as a tutor or assistant.

**CHE 491. Professional Field Experience. 1-18 Hours.**

PR: Consent. (May be repeated up to a maximum of 18 hours.) Prearranged experiential learning program, to be planned, supervised, and evaluated for credit by faculty and field supervisors. Involves temporary placement with public or private enterprise for professional competence development.

**CHE 493. Special Topics. 1-6 Hours.**

PR: Consent. Investigation of topics not covered in regularly scheduled courses.

**CHE 495. Independent Study. 1-6 Hours.**

Faculty supervised study of topics not available through regular course offerings.

**CHE 496. Senior Thesis. 1-3 Hours.**

PR: Consent.

**CHE 497. Research. 1-15 Hours.**

CHE 497. Research. I,II,S. 1-15 hr. PR: Consent. Research activities leading to thesis, problem report, research paper or equivalent scholarly project, or a dissertation. Grading may be S/U.