MEMORANDUM

To: Undergraduate Curriculum Committee
   Dr. Mark Archambault, Chair

Through: Dr. Edward Kalajian, Associate Dean, College of Engineering
         Dr. Manolis Tomadakis, Department Head, Chemical Engineering

From: Dr. Jim Brenner, Assistant Professor, Chemical Engineering

Re: Proposed Nanoscience/Nanotechnology Minor

Date: Nov. 13, 2013

The Department of Chemical Engineering is requesting Undergraduate Curriculum Committee approval to introduce a new Nanoscience/Nanotechnology Minor.

As outlined in the Business Plan of the proposed minor, this new program was made possible thanks to two NSF grants, and has been received very favorably at many national meetings and NSF program reviews. The program will offer more credits of Nanoscience/Nanotechnology Laboratory than any known competitor, and is expected to be a model for Nanoscience and Nanotechnology curricula at other institutions.

Courses to be offered as part of the proposed minor have all been offered at least once before, with consistently high enrollments. Four of those courses were offered previously as Special Topics in CHE, and are now being introduced as new named courses. Although still in its approval process, the new program has already attracted a significant number of students to the Departments of Chemical and Biomedical Engineering, and is expected to attract many more in the future. Six CHE students who will graduate in May 2014 will have completed the minor's requirements.

The suggested Catalog description of the proposed minor is given on the following pages along with the descriptions of the five courses developed for the needs of this program. Four of them are new named courses (three required for the minor and one elective) and all supporting forms and syllabi are attached for your consideration.

The proposed minor requires a minimum of 18 credits, and it will be restricted to students with a GPA of 3.0 or higher. This restriction is placed by the College of Engineering and the Chemical Engineering Department, in line with the University Catalog.
Suggested Catalog Description of Proposed Nanoscience/Nanotechnology Minor:

Nanoscience/Nanotechnology (18 credit hours)

Minor Code: TBD
Age Restriction: N
Delivery Mode(s): classroom only

Degree Awarded: none
Admission status: undergraduate
Location(s): main campus

Ten credits of required courses:
CHE 1091 or CHM 1091 or PHY 1091 Nanoscience/Nanotechnology Lab
CHE 3260 Materials Science and Engineering or BME 3260 Biomaterials
CHE 4563 Materials Characterization Lab
CHE 4567 Nanotechnology

Three or more credits from the following:
CHE 3091 Nanotechnology Lab II
CHE 4569 Biomaterials and Tissue Engineering
Approved Independent Study and/or Undergraduate Research courses in engineering or science

Remaining credit hours:
Restricted Electives

Note: A 3.0 GPA is required for approval to pursue this minor. All above courses are 3 credit hours each, except CHE/CHM/PHY 1091 (1 credit hour) and certain Independent Study and Undergraduate Research courses (1-3 credit hours).

The current list of acceptable Restricted Electives is rather too extensive to be included in the Catalog. It is presented in the following lines for your consideration:

BME 4251 Biomedical Measurements and Instrumentation
CHE 3265 Materials Laboratory
CHM 3002 Physical Chemistry 2
CHM 3302 Analytical Chemistry 2
CWE 3XXX or higher (an approved Cooperative Education course)
ECE 4311 Microelectronics Fabrication Laboratory
EPE 3100 Engineering ProTrack Cooperative Education
OCE 4518 Protection of Marine Materials
PHY 2092 Physics Lab 2
PHY 3035 Quantum Mechanics
PHY 4033 Introduction to Solid State Physics

Notes:
1. All above courses are 3 credit hours each, except CHE 3265 (1 cr.), PHY 2092 (1 cr.), and BME 4251 (4 cr.).

2. The above required and elective minor courses include only 5 credits of named courses in the CHE B.S. major: CHE 3260 (3 cr.), CHE 3265 (1 cr.), and PHY 2092 (1 cr.).
3. A clear path to the proposed minor exists for all majors:

   a. The prerequisites of the required courses CHE/CHM/PHY 1091 and CHE 3260 are general education courses (CHM 1101, PHY 1001, MTH 1002) satisfying the University core requirements for the CHE B.S. Program (next page).

   b. These required courses (CHE/CHM/PHY 1091 and CHE 3260) can in turn satisfy the prerequisite requirements of the other two courses required for the minor (CHE 4563 and CHE 4567), and those of two courses (6 credits) in the second group (CHE 3091 and CHE 4569).

   c. Many Independent Study and Undergraduate Research courses in engineering and science are available with no additional course prerequisites (next page), as are also two of the courses in the Restricted Electives list: ECE 4311 and OCE 4518.

**Catalog Descriptions of New and/or Required Courses for the Proposed Minor**

**CHE 1091 NANOFLUENCE/NANOTECHNOLOGY LAB [Existing course – Required for the minor]**
Introduces science/engineering freshmen interested in careers in nanoscience research/nanotechnology to techniques of nanomaterial fabrication by thin film deposition and chemical synthesis, and sample characterization techniques like atomic force and scanning tunneling microscopes.

**CHE 3091 NANOFLUENCE LAB 2 [New course – Elective for proposed minor]**
Includes self-assembly synthesis, microscopic and spectroscopic characterization, functional evaluation, and aggregation of nanoparticles, nanotubes, coatings, and nanocomposites; biocompatibility, hydrophobicity, photoluminescence, catalysis, magnetic and chemical sensing, and self-diagnosing structural applications.

**CHE 3260 MATERIALS SCIENCE AND ENGINEERING [Existing course – Required for the minor]**
Studies the relationships between materials processing, composition and structure, properties and performance. Includes electrical, mechanical and chemical properties of metals, ceramics, polymers, electronic materials and composites, as well as coating and protection materials.

**CHE 4563 MATERIALS CHARACTERIZATION LAB [New course – Required for proposed minor]**
Emphasizes characterization of nanomaterials using STM, AFM, SEM, TEM, confocal laser scanning microscopy, Raman spectroscopy/microscopy, pore size analysis, and a variety of particle size distribution methods.

**CHE 4567 NANOFLUENCE [New course – Required for proposed minor]**
Studies materials synthesis-structure-function relationships. Emphasizes bulk and surface analytical techniques, catalyst synthesis methods, nanoporous materials, nanoparticles, nanocomposites, carbon nanotubes, nanowires, molecular self-assembly, molecular recognition, biologically inspired materials, and nanomedicine.

**CHE 4569 BIOMATERIALS & TISSUE ENGINEERING [New course – Elective for proposed minor]**
Introduces the principles of materials science and cell biology underlying the design of medical implants, artificial organs, and matrices for tissue engineering.

**Note:** The above two new named lecture courses, CHE 4567 and CHE 4569, are bi-level and will be cross-listed with the existing graduate courses CHE 5567 and CHE 5569, respectively.
Prerequisites for the Four Required Courses (10 credits)

CHE 1091*: CHM 1101 and instructor approval  
CHM 1091*: CHM 1101 and instructor approval  
PHY 1091*: CHM 1101 and instructor approval  
CHE 3260: CHM 1101, PHY 1001, MTH 1002 (co-requisite)  
BME 3260: CHM 2001, PHY 1001, MTH 1002, BIO 1010, BIO 1020  
CHE 4563: [CHE 1091 or CHM 1091 or PHY 1091] and  
[CHE 3260 or BME 3260 or CHM 2002] and junior standing  
CHE 4567: [CHE 3260 or BME 3260 or CHM 2002] and junior standing  
and GPA ≥ 2.75.

Prerequisites for the Second Group of Courses (≥3 credits)

CHE 3091: [CHE 1091 or CHM 1091 or PHY 1091] and  
[CHE 3260 or BME 3260 or CHM 2002] and junior standing  
CHE 4569: [CHE 3260 or BME 3260 or CHM 2002] and junior standing  
and GPA ≥ 2.75.

Some Independent Study courses:

CHE 4291/2**: Senior standing or Dept. Head approval (and CHE 4291 for CHE 4292)  
CIS 5890**: Instructor approval  
CSE 4400**: Instructor approval  
CVE 4095: Dept. Head approval  
ECE 4800: N/A  
MAE 4300/4400: Dept. Head approval  
PHY 4301**: Dept. Head approval  
SPS 4301: Dept. Head approval

Some Undergraduate Research courses:

BIO 4991/2/3: Instructor approval  
CHM 4800/1: Dept. Head approval (and CHM 4800 for CHM 4801)  
EGN 3050**: MTH 1002, PHY 1001, GPA ≥ 3.4, and college faculty approval and  
Associate Dean approval  
MTH 4990: Instructor approval  
OCN 4991/2/3**: Senior standing in oceanography  
PHY 4901/2: Dept. Head approval  
SPS 4901/2: Dept. Head approval

All courses on the left column are 3-credit, except: (*) 1-credit; (**) 1-3 credit
This course is available for student registration only after the approval process has been completed.

SUBJECT CHE COURSE NO.* 3091 CREDIT HOURS 3 TERM TO BE ADDED TO THE FILE Spring 2014 (e.g., CSE) (e.g., 1301) (e.g., Fall 2010)
*Justify level if 1000-level+ and no co- or prerequisites.

CLASS HOURS 5/week LECTURE HOURS 1/week LAB HOURS 4/week CONTACT HOURS (CEU ONLY) 

DEPARTMENT Chemical Engineering SCHEDULE TYPE Lecture/Lab (e.g., Computer Sciences) (e.g., Lecture, Lab or Special Topics/Project)

☐ COLLEGE OF AERONAUTICS – 23 ☐ COLLEGE OF PSYCHOLOGY AND LIBERAL ARTS – 25
☐ NATHAN M. BISK COLLEGE OF BUSINESS – 24 ☐ COLLEGE OF SCIENCE – 26
☐ COLLEGE OF ENGINEERING – 1 ☐ EXTENDED STUDIES / NATHAN M. BISK COLLEGE OF BUSINESS – 90

COMPUTER TITLE Restricted to 25 characters, including spaces Nanotechnology Lab 2 Dual-/prefix, Bi-Level, Full-Load? ☐ Yes ☐ No

CATALOG TITLE Restricted to 350 characters, including spaces Nanotechnology Lab 2

Includes self-assembly synthesis, microscopic/spectroscopic characterization, functional evaluation, and aggregation of nanoparticles, nanotubes, coatings and nanocomposites; biocompatibility, hydrophobicity, photoluminescence, catalysis, magnetic and chemical sensing, and self-diagnosing structural applications.

This description has been approved by the catalog office

Catalog Director Date

In addition, please attach a course syllabus and/or more detailed description.

REQUIREMENTS ☐ Prerequisite BME 3260 ☐ Corequisite __________________ Course Number ☐ and ☐ or
☐ Prerequisite CHE 3260 ☐ Corequisite __________________ Course Number ☐ and ☐ or
☐ Prerequisite CHM 2002 ☐ Corequisite __________________ Course Number ☐ and ☐ or

ADDITIONAL RESTRICTION + and CHE 1081 or CHM 1091 or PHY 1091. Requires junior standing.

GRADES TO BE ISSUED ☐ A, B, C, D, F ☐ A, B, C, D, F, CEU/Audit
☐ CEU ☐ S, U ☐ P, F ☐ Other

If this course replaces a course currently offered in BANNER, please indicate old course information and the date/term the course may be removed from the system.

SUBJECT Prefix (e.g., CSE) ____________________________ COURSE NO. (e.g., 1301) ____________________________ TERM TO INACTIVATE

☐ Yes ☐ No Will this course be used to measure program-level student learning outcomes? If yes, review and signature required.** ☐ Yes ☐ No Will this course be used to satisfy the scholarly inquiry requirement? If yes, attach "Q" materials for review.

APPROVALS: On completion of description and course number verification, affix appropriate signatures as indicated, and submit completed form to Chair, Graduate Council, or Chair, Undergraduate Curriculum Committee for approval.

Originator Date

Chair, Graduate Council Date

Department Head/Program Chair Date

Chair, Undergraduate Curriculum Committee Date

Dean or Associate Dean Date

**Associate Vice President for Institutional Effectiveness Date

REGISTRAR'S USE ONLY

SCARSE SCADTL SCAPREQ SCABASE

SCARRES Operator Init. Date

Florida Institute of Technology • Office of the Registrar

150 West University Boulevard, Melbourne, FL 32901-6975 • (321) 674-8114 • Fax (321) 674-7827

RGR-182-1013
2015-16 Catalog Data: Nanotechnology Lab 2. Self-assembly synthesis, microscopic and spectroscopic characterization, functional evaluation, and aggregation of nanoparticles, nanotubes, coatings, and nanocomposites for biocompatibility, hydrophobicity, photoluminescence, catalysis, magnetic, chemical sensing, and self-diagnosing structural applications.

Credits & Contact Hours: 3 Credits, 14 lectures (50 mins.), 33 lab sessions (110 mins.)

Required or Elective or Selected Elective: Elective for students not taking the Nanotechnology Minor. Restricted elective for students taking the Nanotechnology Minor.

Prerequisite and Co-Requisite Courses: (CHE 3260 OR BME 3260 OR CHM 2002) AND (CHE 1091 OR CHM 1091 OR PHY 1091) AND junior standing.

Prerequisite and Co-Requisite Topics:

1. UV/VIS spectroscopy (in Gen Chem 1, a prerequisite for CHE/CHM/PHY 1091)
2. General Chemistry Lab I wet chemistry
3. General understanding of materials synthesis/structure/function relationships
4. Preliminary exposure to electron and scanning probe microscopies

Textbook (T) and References (R): (R) J. R. Brenner, CHE 3091 CD, August, 2013. Also available at http://my.fit.edu/~jbrenner/nanotechexptdevelopment/. name = fltech password = brenner

Course Outcomes: Upon completion of this course the students will achieve the outcomes as described in LEARNING OUTCOMES CHE 3091.doc (in 2 pages)

1. Materials characterization tools
2. Nanotech syntheses
3. Written communication
4. Environment, safety, and health
5. Multidisciplinary teamwork
6. Oral communication

Topics Covered and Associated Time:
1. Scanning tunneling microscopy (STM) and atomic force microscopy (AFM) (1 lecture)
2. Transmission electron microscopy (TEM) and scanning electron microscopy (SEM) (1 lecture)
3. Confocal laser scanning microscopy (CLSM) with fluorescence, particle size analysis, physisorption and chemisorption (1 lecture)
4. TEM training on carbon nanotubes (CNT’s) grown on an Fe/Al2O3 catalyst and on TiO2 nanoparticles, both prepared by others (1 lab), followed by CNT synthesis (1 lab)
5. SEM training on the periodic porosity of diatoms and both SEM and EDAX (energy dispersive X-ray spectroscopy) on a grid containing multiple metals, as well as CLSM training on commercial CdSe fluorescent nanoparticles (1 lab)
6. STM training on highly oriented pyrolitic graphite
   AFM training on mica, a CD, and a computer chip (1 lab)
7. CdS and CdSe nanoparticle synthesis, followed by SEM, CLSM, TEM, UV/VIS spectroscopy, and particle size analysis (1 lecture + 4 labs)
8. Europia-doped yttria synthesis, followed by TEM and UV/VIS spectroscopy (0.5 lecture + 2 labs)
9. Synthesis of hydrophobic alkanethiol coatings on silver thin films, followed by contact angle measurements, SEM/EDAX, and AFM, as well as direct access in real time (DART) mass spectrometry (1 lecture + 3 labs)
10. Synthesis of monometallic and bimetallic nanoparticles of Fe, Co, and/or Ni followed by TEM and particle size measurements (0.5 lecture + 2 labs)
11. Synthesis of Au nanoparticles, Au nanorods, core/shell silica-encapsulated Au nanorods and biocompatible and silica-encapsulated Au nanorods, followed by TEM, CLSM, UV/VIS and Raman spectrometries, Raman microscopy, and particle size analyses (1 lecture + 4.5 labs)
12. Synthesis of Mo-carbide hydrodenitrogenation (HDN) catalysts, followed by SEM, TEM, liquid nitrogen physisorption, chemisorption, and HDN testing (1 lecture + 2.5 labs)
13. Zeolite synthesis, TEM characterization, liquid nitrogen physisorption, chemisorption, and xylene isomerization catalysis testing (1 lecture + 2.5 labs)
14. Synthesis of polymer/silica nanocomposites and etching of the silica to make templated porous carbons, followed by SEM, TEM, and physisorption (1 lecture + 2.5 labs)
15. Ni nanowire synthesis, TEM, AFM, and magnetic moment measurements (1 lecture + 2 labs)
16. Crash course in National Instruments (NI) data acquisition hardware and software (1 lecture)
17. Synthesis of polymer/carbon nanocomposites, SEM, and electronic nose testing using NI hardware (2 labs)
18. Preparation of microfluidic channels & evaluation of bubble flow through such channels (useful for lab-on-a-chip devices and for approximating biological flows such as with a pulmonary embolism (stroke)) (1 lecture + 2 labs)
19. Technical writing lecture prior to writing of most lab reports (1 lecture)

**Grading:**

Attendance / Lab Execution: 10%; Lab Notebook: 12%; Thirteen Lab Reports: 78%.

The "lab execution" grade will be 100% unless the student does something blatantly unsafe or makes a piece of equipment inoperable for the remainder of the class.

Point criteria listing what must be in each report, at a minimum, will be distributed (as in CHE 3265 Materials Lab). There will also be a generic set of point criteria applicable to all labs. Almost every lab will have at least two nonconsecutive days associated with a given report. Write up what you did as soon as possible, and keep detailed lab notebooks. You will find that a detailed lab notebook will help you understand why things went right or wrong.

**Class Schedule:**

All sections: Monday 12-1 Lab Lecture
Section 1: WF 12-2 Lab Sessions; Section 2: TR 11-1 Lab Sessions

**Relationship of Course Outcomes to Student Outcomes:** See assessment matrix on next page.

**Prepared By:** James R. Brenner, Ph.D., Assistant Professor of Chemical Engineering.
Table 3: Assessment of CHE 3091

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<th>Course Objectives</th>
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Key

A. Ability to apply knowledge of mathematics, science and engineering
B. Ability to design and conduct experiments, as well as to analyze and interpret data
C. Ability to analyze and design a system, component or process to meet desired needs
D. Ability to function in multidisciplinary teams
E. Ability to identify, formulate and solve engineering problems
F. Understanding of professional and ethical responsibility
G. Ability to communicate effectively both orally and in written form
H. Broad education to understand the impact of engineering solutions in a global and societal context
I. Recognition of the need for, and an ability to engage in life-long learning
J. Knowledge of contemporary issues
K. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
L. Knowledge of science appropriate to the goals of the program
M. Working knowledge of process dynamics and control

Program Outcomes: A-K
AICHE Professional Component: K-M

1. Materials Characterization Tools
2. Nanotech Syntheses
3. Written Communication
4. Environment, Safety, and Health
5. Multidisciplinary Teamwork
6. Oral Communication
LEARNING OUTCOMES & ASSESSMENTS FOR CHE 3091

1. 80% of students will be able to conduct basic and intermediate microscopic (TEM, SEM, AFM, and STM) skills, as assessed by direct observation by either the faculty member or a teaching assistant. Each student's understanding of STM, AFM, TEM, and SEM will be upgraded to an intermediate level defined as follows:

   a) Each student can start up, perform most necessary alignments, collect and image, and shut down the equipment under supervision.
   b) Students will know when an SEM or TEM image is out of focus, stigmated, etc., which alignment knobs to adjust (and which not to adjust), and when to ask for assistance.
   c) Students will recognize artifacts in images (e.g. resonance in AFM images; tip dragging in STM and AFM images).
   d) Students will notice pores, non-round crystals, periodicity in structure such as lattice fringe images in TEM and STM, and Moiré fringes.
   e) Students will demonstrate the understanding outlined in b, c, and d both in class and in lab reports.

   In the ABET spreadsheets, this will be called the "Materials Characterization Tools" outcome.

2. 80% of students will successfully conduct a range of syntheses including a) alkanethiol monolayers on nanocrystalline Ag films, b) CdS and CdSe quantum dots, c) carbon nanotubes, d) europia-doped yttria phosphors, e) monometallic and bimetallic nanoparticles, f) Mo carbide hydrodenitrogenation catalysts, g) ZSM-5 zeolites, h) polymer/ceramic nanocomposites, i) templated porous carbons, j) nickel nanowires, and k) microfluidic lab-on-a-chip devices.

   The students will see the results of their syntheses using appropriate materials characterization methods and/or functional evaluation, and if necessary, iterate on their synthesis, characterization, and functional testing until satisfactory results were achieved. This would assure an inquiry-based learning based on others' or their own mistakes, just like one would do in a research environment. In the ABET spreadsheets, this will be called the "Nanotech Syntheses" outcome.

3. 80% of students will be able to effectively write lab reports describing each of the syntheses, results of multiple materials characterization methods, and in some cases, functional testing of either the materials themselves or simple devices made from them. In the ABET spreadsheets, this will be called the "Written Communication" outcome.

4. All two-student groups will be required to score at least an 80 on either written or, more commonly, oral quizzes by either the professor or a teaching assistant prior
to starting many of the syntheses. In the ABET spreadsheets, this will be called the "Environment, Safety, and Health" outcome.

5. For each experiment, students will have to work in teams. The effectiveness of the teamwork will be assessed by self, team, and faculty/TA evaluations during the prelab quiz and as part of the grade for each lab report. These teams will be periodically changed up to assure that students are able to work effectively in multidisciplinary teams. In the ABET spreadsheets, this will be called the "Multidisciplinary Teamwork" outcome.

6. The same prelab quizzes described in item 4 will be used to assess the effectiveness of students' oral communication skills. In the ABET spreadsheets, this will be called the "Oral Communication" outcome.
This course is available for student registration only after the approval process has been completed.

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<th>CREDIT HOURS</th>
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*Justify level if 1000-level+ and no co- or prerequisites

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<th>CLASS HOURS</th>
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DEPARTMENT: Chemical Engineering

- (e.g., Computer Sciences)
- SCHEDULE TYPE: Lecture/Lab

- COLLEGE OF AERONAUTICS – 23
- NATHAN M. BISK COLLEGE OF BUSINESS – 24
- COLLGE OF ENGINEERING – 1
- COLLEGE OF PSYCHOLOGY AND LIBERAL ARTS – 25
- COLLEGE OF SCIENCE – 26
- EXTENDED STUDIES / NATHAN M. BISK COLLEGE OF BUSINESS – 90

COMPUTER TITLE: Restricted to 25 characters, including spaces

Materials Character Lab

Dual-Prefix, Bi-Level, Full-Load? Yes [ ] No [ ]

CATALOG TITLE: Restricted to 350 characters, including spaces

Emphasizes characterization of nanomaterials using STM, APM, SEM, TEM, confocal laser scanning microscopy, Raman spectroscopy/microscopy, pore size analysis and a variety of particle size distribution methods.

This description has been approved by the catalog office

Catalog Director [Signature] Date 11/13/13

In addition, please attach a course syllabus and/or more detailed description.

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- and [ ] or

AND CHE 1091 OR CHM 1091 OR PHY 1091. Requires junior standing.

SUBJECT Alpha Prefix (e.g., CSE) COURSE NO. (e.g., 1301) TERM TO INACTIVATE

- Yes [ ] No Will this course be used to measure program-level student learning outcomes? If yes, review and signature required.

APPROVALS: On completion of description and course number verification, affix appropriate signatures as indicated, and submit completed form to Chair, Graduate Council, or Chair, Undergraduate Curriculum Committee for approval.

Originator [Signature] Date 1/4/18

Chair, Graduate Council [Signature] Date

Department Head/Program Chair [Signature] Date 11-13-13

Chair, Undergraduate Curriculum Committee [Signature] Date

**Associate Vice President for Institutional Effectiveness

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RGR-182-1012
CHE 4563 Materials Characterization Laboratory

2015-16 Catalog Data: Materials Characterization Laboratory. Emphasizes characterization of nanomaterials using STM, AFM, SEM, TEM, confocal laser scanning microscopy, Raman spectroscopy/microscopy, pore size analysis, and a variety of particle size distribution methods.

Credits & Contact Hours: 3 Credits, 15 lectures (50 mins.), 30 lab sessions (110 mins.)

Required or Elective or Selected Elective: Elective for students not taking the Nanotechnology Minor. Required for students taking the Nanotechnology Minor.

Prerequisite and Co-Requisite Courses: (CHE 3260 OR BME 3260 OR CHM 2002) AND (CHE 1091 OR CHM 1091 OR PHY 1091) AND junior standing.

Prerequisite and Co-Requisite Topics:

1. UV/VIS spectroscopy (in Gen Chem 1, a prerequisite for CHE/CHM/PHY 1091)
2. General Chemistry Lab I wet chemistry
3. General understanding of materials synthesis/structure/function relationships
4. Preliminary exposure to electron and scanning probe microscopies

Textbook (T) and References (R): (R) J. R. Brenner, CHE 4563 CD, August, 2013. Also available at http://my.fit.edu/~jbrenner matchar name = fltech password = brenner

Course Outcomes: Upon completion of this course the students will achieve the outcomes as described in LEARNING OUTCOMES CHE 4563.doc (in 2 pages)

1. Materials characterization theory
2. Materials characterization practice
3. Materials characterization selection
4. Image analysis
5. Independent study
6. Equipment respect

Topics Covered and Associated Time:

1. Scanning tunneling microscopy (STM) and atomic force microscopy (AFM) (1 lecture)
2. Transmission electron microscopy (TEM) and scanning electron microscopy (SEM) (1 lecture)
3. Confocal laser scanning microscopy (CLSM) with fluorescence, particle size analysis, physisorption and chemisorption (1 lecture)
4. Basic TEM training (2 labs)
5. Basic SEM and EDAX (energy dispersive X-ray spectroscopy) training (2 labs)
6. Basic CLSM training (1 lab)
7. Basic STM training (1 lab)
8. Basic AFM training (3 labs)
9. Fundamentals of spectroscopy (1 lecture)
10. UV/VIS spectroscopy, Raman spectroscopy, and EDAX (1 lecture)
11. Basic Raman spectroscopy and microscopy training (1 lab)
12. Raman microscopy specific to Au nanoparticles for biomedical imaging (1 lecture + 1 lab)
14. Other Au nanoparticle characterization (SEM, CLSM, TEM, UV/VIS, particle size analysis) (2 labs)
15. Quantum dot and phosphorescent nanoparticles SEM, CLSM, TEM, UV/VIS spectroscopy, and particle size analysis (1 lecture + 3 labs) (8,19)
16. Synthesis of hydrophobic alkanethiol coatings on silver thin films, followed by contact angle measurements, SEM/EDAX, and AFM, as well as direct access in real time (DART) mass spectrometry (0.5 lecture + 3 labs)
17. Image analysis (2 lectures) (10.5 and 22)
18. Self-assembly and aggregation of zeolites (1 lecture + 2 labs) (11.5, 24)
19. Self-assembly and aggregation of proteins associated with Alzheimer’s disease (1 lecture + 2 labs)
20. End-of-semester project (0.5 lecture + 4 labs)
21. Materials characterization tool selection (2 lectures)

Grading:
The grading in this course will be based on an unusual points system that I have modified from Dr. John Burmeister’s Gen Chem 2 Honors class at The University of Delaware. If no due date is listed below, then the student is expected to schedule an appointment (preferably during normal class times) for that activity. Students must get an 80 on equipment-specific take home exams to be able to work on that particular type of equipment, with the opportunity for one retake. If a student fails twice, he/she is not allowed to work on that piece of equipment. This is meant to ensure that students will properly respect expensive multiuser equipment.

<table>
<thead>
<tr>
<th>Assignment/Quiz/Hands-on Practical Test</th>
<th>Due Date (if any)</th>
<th>Max # of Pts.</th>
</tr>
</thead>
<tbody>
<tr>
<td>STM/AFM Take-Home Test</td>
<td>2nd Friday</td>
<td>6</td>
</tr>
<tr>
<td>SEM/TEM Take-Home Test</td>
<td>3rd Friday</td>
<td>6</td>
</tr>
<tr>
<td>Wk. 13 HW</td>
<td>following Monday</td>
<td>3</td>
</tr>
<tr>
<td>Wks. 14-15 HW</td>
<td>last day of classes</td>
<td>3</td>
</tr>
<tr>
<td>SEM Use other than Sample Prep/(Un)load</td>
<td>fifth Thurs./Fri. preferred</td>
<td>3</td>
</tr>
<tr>
<td>TEM Use other than Sample Prep/(Un)load</td>
<td>sixth Thurs./Fri. preferred</td>
<td>3</td>
</tr>
<tr>
<td>Acquiring an STM Image with Precut Tip</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Acquiring an STM Image with Own Tip</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Acquiring an AFM Image</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Acquiring an AFM Image w/Own Tip</td>
<td></td>
<td>3</td>
</tr>
<tr>
<td>Sample Prep for STM or AFM + Image</td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>Sample Prep for TEM of Powders + Image</td>
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<td>3</td>
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<tr>
<td>Sample Prep for SEM + Image</td>
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<td>3</td>
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<tr>
<td>Acquiring Confocal Microscopy Image sixth Tuesday preferred</td>
<td></td>
<td>3</td>
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<tr>
<td>Additional samples analyzed</td>
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<td>3/sample</td>
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<tr>
<td>Image Analysis (Particle Size Count) HW</td>
<td></td>
<td>3</td>
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<tr>
<td>Image Analysis Own Sample</td>
<td></td>
<td>3/sample</td>
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<tr>
<td>Other Methods: DART-MS, porosimetry, chemisorption, TPD</td>
<td></td>
<td>6 each</td>
</tr>
<tr>
<td>Develop Own Experiment that demonstrates self-assembly</td>
<td></td>
<td>10 each</td>
</tr>
</tbody>
</table>
Getting an STM or AFM up and running 3 each if running
" " " " 8 each if you repair it
Training Other Students 1/hour

30-34 pts. for D, 35-43 pts. for C, 44-55 pts. for B, ≥ 56 pts. for an A

If equipment downtime is encountered, the above point cutoff totals will be reduced accordingly.

**Class Schedule:**

All sections: Monday 12-1 Lab Lecture  
Section 1: WF 2-3 Lab Sessions; Section 2: TR 11-1 Lab Sessions

**Relationship of Course Outcomes to Student Outcomes:** See assessment matrix on next page.

**Prepared By:** James R. Brenner, Ph.D., Assistant Professor of Chemical Engineering.
<table>
<thead>
<tr>
<th>Course Objectives</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
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</tbody>
</table>

Key
A. Ability to apply knowledge of mathematics, science and engineering
B. Ability to design and conduct experiments, as well as to analyze and interpret data
C. Ability to analyze and design a system, component or process to meet desired needs
D. Ability to function in multidisciplinary teams
E. Ability to identify, formulate and solve engineering problems
F. Understanding of professional and ethical responsibility
G. Ability to communicate effectively both orally and in written form
H. Broad education to understand the impact of engineering solutions in a global and societal context
I. Recognition of the need for, and an ability to engage in life-long learning
J. Knowledge of contemporary issues
K. Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
L. Knowledge of science appropriate to the goals of the program
M. Working knowledge of process dynamics and control

Program Outcomes: A-K
AIChE Professional Component: K-M

1. Materials Characterization Theory
2. Materials Characterization Practice
3. Materials Characterization Selection
4. Image Analysis
5. Independent Research
6. Equipment Respect
LEARNING OUTCOMES & ASSESSMENTS FOR CHE 4563

1. All students will be required to pass written exams on both the theory and practice of microscopic (TEM, SEM, AFM, and STM) skills before the students will be permitted to work on any of the instruments. In the ABET spreadsheets, this will be called the "Materials Characterization Theory" outcome.

2. 100% of students will be able to be able to conduct basic and intermediate microscopic (TEM, SEM, AFM, STM, and confocal microscopy with fluorescence) skills, as assessed by direct observation by either the faculty member or a teaching assistant. Each students' understanding of each of the microscopies will be upgraded to an intermediate level defined as follows:

   a) Each student can start up, perform most necessary alignments, collect and image, and shut down the equipment under supervision.
   b) Students will know when an SEM or TEM image is out of focus, stigmatized, etc., which alignment knobs to adjust (and which not to adjust), and when to ask for assistance.
   c) Students will recognize artifacts in images (e.g. resonance in AFM images; tip dragging in STM and AFM images).
   d) Students will notice pores, non-round crystals, periodicity in structure such as lattice fringe images in TEM and STM, and Moiré fringes.
   e) Students will demonstrate the understanding outlined in b, c, and d both in class and in lab reports.

   In the ABET spreadsheets, this will be called the "Materials Characterization Practice" outcome.

3. All students will be given both a homework assignment and a set of exam problems where they will be given a class of nanomaterials and a set of information to be obtained for that class of nanomaterials. Eighty percent of the students will be expected to get a score of at least an 80 with regard to a) materials analytical tool selection, b) justification regarding why the particular tool was selected, and c) a description of the advantages and limitations of the tool selection. In the ABET spreadsheets, this will be called the "Materials Characterization Selection" outcome.

4. Eighty percent of students will be able to get at least an 80 on two image analysis problems as part of a take home exam for either image enhancement and/or particle size distribution analysis.

5. All students will conduct an end-of-semester independent or group project in which they will characterize a material not covered in class with one of the analytical tools mastered earlier in the course. Eighty percent of the students will successfully complete this project with at least a score of 80. In the ABET spreadsheets, this will be called the "Independent Research" outcome.
6. All students will show appropriate respect for the equipment and for each other's ability to conduct experiments on the same equipment on a long term basis. This will be exemplified by less than 20% of the students making preventable mistakes that result in equipment malfunction even once and none of them making such preventable mistakes twice.
# Adding a New Course to the Curriculum

**Florida Institute of Technology**

**This course is available for student registration only after the approval process has been completed.**

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>COURSE NO.*</th>
<th>CREDIT HOURS</th>
<th>TERM TO BE ADDED TO THE FILE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE 4567</td>
<td>3</td>
<td>Spring 2014</td>
<td></td>
</tr>
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*(Justify if 1000-level+ and no co- or prerequisites.)*

<table>
<thead>
<tr>
<th>CLASS HOURS</th>
<th>LECTURE HOURS</th>
<th>LAB HOURS</th>
<th>CONTACT HOURS (CEU ONLY)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3/week</td>
<td>3/week</td>
<td></td>
<td></td>
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</tbody>
</table>

**DEPARTMENT**

Chemical Engineering

**SCHEDULE TYPE**

Lecture

**COLLEGE OF AERONAUTICS – 23**

**NATHAN M. BISK COLLEGE OF BUSINESS – 24**

**COLLEGE OF ENGINEERING – 1**

**COLLEGE OF PSYCHOLOGY AND LIBERAL ARTS – 25**

**COLLEGE OF SCIENCE – 26**

**EXTENDED STUDIES / NATHAN M. BISK COLLEGE OF BUSINESS – 90**

**COMPUTER TITLE**

Restrained to 25 characters, including spaces

Nanotechnology

**Nanotechnology**

**CATALOG DESCRIPTION OF COURSE**

Restrained to 350 characters, including spaces

Studies materials synthesis-structure-function relationships. Emphasizes bulk and surface analytical techniques, catalyst synthesis methods, nanoporous materials, nanoparticles, nanocomposites, carbon nanotubes, nanowires, molecular self-assembly, molecular recognition, biologically inspired materials and nanomedicine.

This description has been approved by the catalog office. **E. Jo 11/3/13**

**In addition, please attach a course syllabus and/or more detailed description.**

**RESTRICTIONS**

- Prerequisite: BME 3260
- Prerequisite: CHE 3260
- Prerequisite: CHM 2002

**ADDITIONAL RESTRICTION**

Requires junior standing and 2.75 GPA.

**GRADES TO BE ISSUED**

A, B, C, D, F

A, B, C, D, F, CEU/Audit

CEU

S, U

P, F

Other

**If this course replaces a course currently offered in BANNER, please indicate old course information and the date/term the course may be removed from the system.**

**SUBJECT Alpha Prefix (e.g., CSE) COURSE NO. (e.g., 1301) TERM TO INACTIVATE**

**APPROVALS:** On completion of description and course number verification, affix appropriate signatures as indicated, and submit completed form to Chair, Graduate Council, or Chair, Undergraduate Curriculum Committee for approval.

**Registrar’s Use Only**

SCACRESE SCADETL SCAPREQ SCABASE

SCARRES Operator Init. Date

**Florida Institute of Technology • Office of the Registrar**

150 West University Boulevard, Melbourne, FL 32901-6975 • (321) 674-8114 • Fax (321) 674-7827
CHE 4577 Nanotechnology

2015-16 Catalog Data: Nanotechnology. Studies materials synthesis-structure-function relationships, emphasizing bulk and surface analytical techniques, catalyst synthesis methods, nanoporous materials, nanoparticles, nanocomposites, carbon nanotubes, nanowires, molecular self-assembly, molecular recognition, biologically inspired materials, and nanomedicine.

Credits & Contact Hours: 3 Credits, 16 lectures (150 mins.), including one highly recommended three-hour review of prerequisite topics before class officially starts.

Required or Elective or Selected Elective: Elective for students not taking the Nanotechnology Minor. Required for students taking the Nanotechnology Minor.

Prerequisite and Co-Requisite Courses: (CHE 3260 OR BME 3260 OR CHM 2002) AND junior standing AND 2.75 GPA.

Prerequisite and Co-Requisite Topics:

1. Chemistry/biochemistry – chirality, valence, spectroscopy, electronegativity, types of bonds (including hydrogen bonding), chemical reaction kinetics, equilibrium constant, organic biochemistry of esters, alcohols, amines, and alkanethiols.
2. Analytic geometry – surface area to volume ratio
3. Thermodynamics – enthalpy, Gibbs free energy
4. Materials science – properties of polymers, metals, and ceramics, time-temperature-transformations, x-ray diffraction, electrical conduction, band gap energy,
5. Engineering – PowerPoint presentation skills, fluid mechanics (desired), heat transfer (desired)

Textbook (T) and References (R): (R) J. R. Brenner, CHE 4577 CD (a compilation of relevant literature), April, 2013. Also available at http://my.fit.edu/~jbrenner/nanotechnology name = fltech password = brenner

Course Outcomes: Upon completion of this course the students will achieve the outcomes as described in LEARNING OUTCOMES CHE 4577.doc (in 2 pages)

1. Electrical and optical properties vs. size
2. Materials characterization tools
3. Customized synthesis
4. Sensors
5. Discipline-specific science
6. Literature search
7. Questions and issues sheet
8. Oral literature review
9. Multidisciplinary teamwork

Topics Covered and Associated Time:
1. Review of prerequisite topics (1 lecture)
2. Nanotechnology introductory concepts, motivation, and history (0.6 lecture)
3. Microscopic characterization of surfaces and nanoparticles (0.3 lecture)
4. Nanotribology (0.1 lecture)
5. Catalyst synthesis-structure-function relationships (2/3 lecture)
6. Porous non-catalysts (1/3 lecture)
7. Nanocomposites (0.2 lecture)
8. Nanoparticles (0.5 lecture)
9. Environmental hazards of nanotechnology (0.3 lecture)
10. Protein misfolding (0.3 lecture)
11. DNA origami (0.1 lecture)
12. Molecular self-assembly (0.6 lecture)
13. Odd shapes and nanomachines (0.5 lecture)
14. Carbon nanotube synthesis, solubilization, purification, and use (1 lecture)
15. Nanomanipulation and nanolithography (0.5 lecture)
16. Nanoelectronics, data storage, and nanowires (1 lecture)
17. Nanophotonics and quantum dots (0.8 lecture)
18. Nanoelectromechanical (NEMS) resonators (0.2 lecture)
19. Microfluidics, Lab-on-a-Chip Devices, and Microreactors (0.3 lecture)
20. How to conduct a thorough literature review (0.3 lecture)
21. Energy storage and use (0.3 lecture)
22. Entrepreneurship (0.1 lecture)
23. Sensors (2/3 lecture)
24. Molecularly imprinted polymers (1/3 lecture)
25. Biologically-inspired materials (0.5 lecture)
26. Marine antibiofouling (0.2 lecture)
27. Nanobiological transport (0.3 lecture)
28. Implants and tissue regeneration (0.6 lecture)
29. Nanomedicine (1.2 lectures)
30. Cellular transmembrane signaling (0.2 lecture)
31. End of semester multidisciplinary group project presentations (1 lecture + final exam slot)

Grading:
- Grades: 90 for an A, 80 for a B, 70 for a C, etc.
- Homework - 30%
- Test 1 is take home over spring break - 30%
- Comprehensive Book Chapter/Literature Review on course topic (multidisciplinary end-of-semester group project oral presentation) instead of a final exam: 40%

Class Schedule: Wednesday 6:30 – 9:15 PM with 15 minute break

Relationship of Course Outcomes to Student Outcomes: See assessment matrix on next page.

Prepared By: James R. Brenner, Ph.D., Assistant Professor of Chemical Engineering.
### Table 6: Assessment of CHE 4567 - Nanotechnology

<table>
<thead>
<tr>
<th>Course Objectives</th>
<th>Student Outcomes/Professional Component/Departmental Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>1</td>
<td>♦</td>
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<td>8</td>
<td>♦</td>
</tr>
<tr>
<td>9</td>
<td>♦</td>
</tr>
</tbody>
</table>

Key:
- A: Ability to apply knowledge of mathematics, science and engineering
- B: Ability to design and conduct experiments, as well as to analyze and interpret data
- C: Ability to analyze and design a system, component or process to meet desired needs
- D: Ability to function in multidisciplinary teams
- E: Ability to identify, formulate and solve engineering problems
- F: Understanding of professional and ethical responsibility
- G: Ability to communicate effectively both orally and in written form
- H: Broad education to understand the impact of engineering solutions in a global and societal context
- I: Recognition of the need for, and an ability to engage in lifelong learning
- J: Knowledge of contemporary issues
- K: Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
- L: Knowledge of science appropriate to the goals of the program
- M: Working knowledge of process dynamics and control

Program Outcomes: A-K
AIChe Professional Component: K-M

1. Electrical & Optical Properties vs. Size
2. Materials Characterization Tools
3. Customized Synthesis
4. Sensors
5. Discipline-Specific Science
6. Literature Search
7. Questions and Issues
8. Oral Literature Review
9. Multidisciplinary teamwork

♦ = lightly addressed
♦ = strongly addressed
LEARNING OUTCOMES & ASSESSMENTS FOR CHE 4567

1. 90% of students will demonstrate an understanding of the relationship between the size of particles and rods in which electrons can be confined with the resulting material's electronic and optical properties as assessed by a grade of 80% on relevant sections of the 1st hourly exam, including interpretation of literature data and calculation of band gap energies or particle dimensions from spectral data. In the ABET spreadsheets, this will be called the "Electrical/optical properties vs. size" outcome.

2. 90% of students will be able to graphically demonstrate the relationships between pH, particle size, and zeta potential (surface charge) and be able to compare and contrast the advantages and limitations of different types of microscopy (TEM, SEM, AFM, STM, confocal laser scanning microscopy), particle size analysis, and spectroscopic equipment as assessed by a grade of 80% on relevant sections of the 1st hourly exam. In the ABET spreadsheets, this will be called the "Materials Characterization Tool Selection" outcome.

3. 90% of students will be able to make a list of nanoparticle capping agents, be able to list the steps in a nanoparticle or porous material or coating preparation, including selection of templating agents, and be able to explain the reasons why certain reagents are chosen (biocompatibility, corrosion resistance, hydrophobicity, hydrophilicity, receptors for chemical and biological sensors as well as cell targeting, penetration of the blood-brain barrier, catalysis, etc.). This will be assessed by a grade of 80% on relevant sections of the 1st hourly exam. In the ABET spreadsheets, this will be called the "Customized synthesis" outcome.

4. 90% of students will be able to list the steps necessary in making customized sensors such as lab-on-a-chip devices, and be able to compare/contrast the advantages and limitations of various sensing modalities. This will be assessed by a grade of 80% on relevant sections of the 1st hourly exam. In the ABET spreadsheets, this will be called the "Sensors" outcome.

5. 90% of students will be able to demonstrate an understanding of the materials science, chemistry, biology, and physics of the nanotechnology literature. This will be assessed by a grade of 90% on each of the completed homeworks, 80% on relevant sections of the 1st hourly exam, and 80% on the final presentation. In the ABET spreadsheets, this will be called the "Discipline-Specific Science" outcome.

6. All students will be able to conduct a thorough literature search using Web of Knowledge and RefWorks, as assessed by an e-mail list of the appropriate references for their end-of-semester project. In the ABET spreadsheets, this will be called the "Literature Search" outcome.

7. 100% of student groups will be able to define a problem using a "questions and
issues sheet" listing a minimum of 25 technical/engineering, health, safety, environment, legal, regulatory, social impact, quality, and economic issues, with at least two issues per category. In the ABET spreadsheets, this will be called the "Questions and Issues" outcome.

8. All students will be able to conduct a thorough examination and summary of the literature as assessed in a end-of-semester multidisciplinary group project. All students will prepare PowerPoint slides of that literature for their end-of-semester presentation and then make the presentation in a logical order and free of technical errors, as assessed by an 80 on the students' presentations. In the ABET spreadsheets, this will be called the "Oral Literature Review" outcome.

9. 90% of students will be able to function properly in multidisciplinary teams as assessed by self, team, and faculty evaluations of their performance as being "acceptable" on the end of semester project. In the ABET spreadsheets, this will be called the "multidisciplinary team" outcome.
**Florida Institute of Technology**

**ADDING A NEW COURSE TO THE CURRICULUM**

This course is available for student registration only after the approval process has been completed.

**SUBJECT** CHE  
**COURSE NO.** 4569 (e.g., 1301)  
**CREDIT HOURS** 3  
**TERM TO BE ADDED TO THE FILE** Spring 2014 (e.g., Fall 2010)

**CLASS HOURS** 3/week  
**LECTURE HOURS** 3/week  
**LAB HOURS**  
**CONTACT HOURS (CEU ONLY)**

**DEPARTMENT** Chemical Engineering (e.g., Computer Sciences)  
**SCHEDULE TYPE** Lecture (e.g., Lecture, Lab or Special Topics/Project)

- [ ] COLLEGE OF AERONAUTICS – 23  
- [ ] COLLEGE OF PSYCHOLOGY AND LIBERAL ARTS – 25  
- [ ] COLLEGE OF SCIENCE – 26  
- [ ] EXTENDED STUDIES / NATHAN M. BISK COLLEGE OF BUSINESS – 90

**COMPUTER TITLE** Restricted to 25 characters, including spaces: 
Biomaterials Tissue Eng  
**Dual Prefix? Bi-Level? Full-Load?**  
[ ] Yes  
[ ] No

**CATALOG TITLE** Restricted to 350 characters, including spaces: 
Biomaterials Tissue Engineering

**CATALOG DESCRIPTION OF COURSE** Restricted to 350 characters, including spaces: 
Introduces the principles of materials science and cell biology underlying the design of medical implants, artificial organs and matrices for tissue engineering.

This description has been approved by the catalog office:  
[Signature]  
**Date** 11/13/13

In addition, please attach a course syllabus and/or more detailed description.

**RESTRICTIONS**  
- [ ] Prerequisite: BME 3260  
- [ ] Corequisite: 
- [ ] Course Number  
- [ ] and or  

**GRADES TO BE ISSUED**  
[ ] A, B, C, D, F  
[ ] A, B, C, D, F, CEU/Audit  
[ ] CEU  
[ ] S, U  
[ ] P, F  
[ ] Other

**ADDITIONAL RESTRICTION**  
Requires junior standing and 2.75 GPA.

If this course replaces a course currently offered in BANNER, please indicate old course information and the date/term the course may be removed from the system.

**SUBJECT Alpha Prefix (e.g., CSE)**  
**COURSE NO.** (e.g., 1301)  
**TERM TO INACTIVATE**

[ ] Yes  
[ ] No  
Will this course be used to measure program-level student learning outcomes? If yes, review and signature required.

**APPROVALS:** On completion of description and course number verification, affix appropriate signatures as indicated, and submit completed form to Chair, Graduate Council, or Chair, Undergraduate Curriculum Committee for approval.

**Originator**  
**Date** 11/14/13

**Department Head/Program Chair**  
**Date** 11/13/13

**Dean of Associate Dean**  
**Date** 11/13/13

**Associate Vice President for Institutional Effectiveness**  
**Date**

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Operator Init.  
**Date**

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RGR-182-1013
CHE 4569 Biomaterials and Tissue Engineering

2015-16 Catalog Data: Biomaterials and Tissue Engineering. Introduces the principles of materials science and cell biology underlying the design of medical implants, artificial organs, and matrices for tissue engineering.

Credits & Contact Hours: 3 Credits, 16 lectures (150 mins.), including one highly recommended three-hour review of prerequisite topics before class officially starts.

Required or Elective or Selected Elective: Elective for students not taking the Nanotechnology Minor. Restricted elective for students taking the Nanotechnology Minor.

Prerequisite and Co-Requisite Courses: (CHE 3260 OR BME 3260 OR CHM 2002) AND junior standing AND 2.75 GPA.

Prerequisite and Co-Requisite Topics:

1. Chemistry/biochemistry – chirality, valence, spectroscopy, electronegativity, types of bonds (including hydrogen bonding), chemical reaction kinetics, equilibrium constant, organic biochemistry of esters, alcohols, amines, and alkanethiols.
2. Analytic geometry – surface area to volume ratio
3. Thermodynamics – enthalpy, Gibbs free energy
4. Materials science – properties of polymers, metals, and ceramics, time-temperature-transformations, x-ray diffraction, electrical conduction, band gap energy,
5. Engineering – PowerPoint presentation skills, fluid mechanics (desired), heat transfer (desired)
6. Biology – very basic anatomy and physiology


Course Outcomes: Upon completion of this course the students will achieve the outcomes as described in LEARNING OUTCOMES CHE 4569.doc (in 2 pages)

1. Biomaterials selection
2. Materials characterization tools
3. Customized synthesis
4. Implant validation
5. Tissue engineering validation
6. Sensors
7. Discipline-specific science
8. Literature search
9. Questions and issues sheet
10. Oral literature review
11. Multidisciplinary teamwork
Topics Covered and Associated Time:
1. Review of prerequisite topics (1 lecture)
2. Viscoelastic behavior of biomaterials (0.5 lecture)
3. Microscopic and spectroscopic materials characterization (0.5 lecture)
4. Polymeric materials, including natural materials (1 lecture)
5. Surface chemistry for prevention and enhancement of adhesion (1 lecture)
6. Barriers to molecular and cellular transport (0.5 lecture)
7. Applications of microfluidics to cells (0.5 lecture)
8. Biodegradation mechanisms (1/3 lecture)
9. Mechanical, porosity, and transport properties of biodegradable polymer scaffolding substrates for tissue engineering (2/3 lecture)
10. Targeted drug delivery; noninvasive imaging of drug delivery packets, tumors, and implants (1 lecture)
11. Cells, cell injury, tissues, the extracellular matrix, and cell-biomaterial interactions (1 lecture)
12. The immune response, inflammation, surface and protein interactions (0.5 lecture); Wound healing; wound dressings and sutures, and infections (0.5 lecture)
13. Entrepreneurship (0.2 lecture)
14. How to perform a thorough literature review (0.3 lecture)
15. Knee and hip replacements; eye and ear implants; dental implants (0.5 lecture)
16. Cardiovascular devices (0.5 lecture)
17. Artificial red blood cells and phagocytes (0.3 lecture)
18. Skin grafts and substitutes (0.2 lecture)
19. Biomedical sensors and biosensors (1 lecture)
20. Overview of and approaches to tissue engineering, particularly bone and nerve regeneration using adult stem cells with emphasis on electrospinning and 3D printing synthesis methods (2 lectures)
21. Bone loss in astronauts and seniors, how to prevent it, and how to counteract its effects (1 lecture)
22. End of semester multidisciplinary group project presentations (1 lecture + final exam slot)

Grading:
Grades: 90 for an A, 80 for a B, 70 for a C, etc.
Homework - 30%  Test 1 is take home over spring break - 30%
Comprehensive Book Chapter/Literature Review on course topic (multidisciplinary end-of-semester group project oral presentation) instead of a final exam: 40%

Class Schedule: Wednesday 6:30 – 9:15 PM with 15 minute break

Relationship of Course Outcomes to Student Outcomes: See assessment matrix on next page.

Prepared By: James R. Brenner, Ph.D., Assistant Professor of Chemical Engineering.
Table 7: Assessment of 4569 - Biomaterials and Tissue Regeneration

<table>
<thead>
<tr>
<th>Learning Objectives</th>
<th>Student Outcomes/Professional Component/Departmental &amp; NST Program Objectives</th>
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Key Description

A Ability to apply knowledge of mathematics, science and engineering
B Ability to design and conduct experiments, as well as to analyze and interpret data
C Ability to analyze and design a system, component or process to meet desired needs
D Ability to function in multidisciplinary teams
E Ability to identify, formulate and solve engineering problems
F Understanding of professional and ethical responsibility
G Ability to communicate effectively both orally and in written form
H Broad education to understand the impact of engineering solutions in a global and societal context
I Recognition of the need for, and an ability to engage in life-long learning
J Knowledge of contemporary issues
K Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice
L Knowledge of science appropriate to the goals of the program
M Working knowledge of process dynamics and control

Program Outcomes: A-K
AICHE Professional Component: K-M

1 Biomaterials Selection
2 Materials Characterization Tools
3 Customized Synthesis
4 Implant Validation
5 Tissue Engineering Validation
6 Sensors
7 Discipline-Specific Science
8 Literature Search
9 Questions and Issues
10 Oral Literature Review
11 Multidisciplinary teamwork
LEARNING OUTCOMES & ASSESSMENTS FOR CHE 4569

1. 90% of students will generate a list of possible biomaterials selection options for a range of different replacement body parts or organs, as assessed by a grade of 80% on relevant sections of the 1st hourly exam and relevant homeworks. In the ABET spreadsheets, this will be called the "Biomaterials Selection" outcome.

2. 90% of students will be able to interpret microscopic (TEM, SEM, AFM, STM, confocal laser scanning microscopy), particle size analysis, and spectral data as assessed by a grade of 80% on relevant sections of the 1st hourly exam. In the ABET spreadsheets, this will be called the "Materials Characterization Tools" outcome.

3. 90% of students will be able to put together a preliminary synthesis procedure that combines biomedical imaging and either targeted drug delivery or targeted radiation therapy. The students will be able to explain the reasons why certain reagents are chosen (biocompatibility, immune resistance, thromboresistance, lack of immune system provocation, hydrophobicity, hydrophilicity, receptors for chemical and biological sensors as well as cell targeting, penetration of the blood-brain barrier, etc.). This will be assessed by a grade of 80% on relevant sections of the 1st hourly exam. In the ABET spreadsheets, this will be called the "Customized synthesis" outcome.

4. 90% of students will be able to compare and contrast alternate implantation materials selection and procedures and be able to diagnose the successful implantation with its surroundings (cell-biomaterial interactions particularly the extracellular matrix, wound healing, measures of surrounding cell injury, lack of significant immune response and/or inflammation, presence or absence of infections, etc.). The students will be required to explain the basis for their selections. This will be assessed by a grade of 80% on relevant sections of the 1st hourly exam. In the ABET spreadsheets, this will be called the "Implant validation" outcome.

5. 90% of students will be able to compare and contrast alternate synthesis procedures for preparing tissue scaffolding, for culturing cells on the tissue scaffolding into replacement organs, and for diagnosing the successful integration of the new tissue with its surroundings (cell-biomaterial interactions particularly the extracellular matrix, wound healing, measures of surrounding cell injury, lack of significant immune response and/or inflammation, presence or absence of infections, etc.). The students will be required to explain the basis for their selections. This will be assessed by a grade of 80% on relevant sections of the 1st hourly exam. In the ABET spreadsheets, this will be called the "Tissue engineering validation" outcome.

6. 90% of students will be able to list the steps necessary in making customized sensors such as lab-on-a-chip devices, and be able to compare/contrast the advantages
and limitations of various sensing modalities. This will be assessed by a grade of 80% on relevant sections of the 1st hourly exam. In the ABET spreadsheets, this will be called the "Sensors" outcome.

7. 90% of students will be able to demonstrate an understanding of the materials science, chemistry, biology, and physics of the nanotechnology literature. This will be assessed by a grade of 90% on each of the completed homeworks, 80% on relevant sections of the 1st hourly exam, and 80% on the final presentation. In the ABET spreadsheets, this will be called the "Discipline-Specific Science" outcome.

8. All students will be able to conduct a thorough literature search using Web of Knowledge and RefWorks, as assessed by an e-mail list of the appropriate references for their end-of-semester project. In the ABET spreadsheets, this will be called the "Literature Search" outcome.

9. 100% of student groups will be able to define a problem using a "questions and issues sheet" listing a minimum of 25 technical/engineering, health, safety, environment, legal, regulatory, social impact, quality, and economic issues, with at least two issues per category. In the ABET spreadsheets, this will be called the "Questions and Issues" outcome.

10. All students will be able to conduct a thorough examination and summary of the literature as assessed in a end-of-semester multidisciplinary group project. All students will prepare PowerPoint slides of that literature for their end-of-semester presentation and then make the presentation in a logical order and free of technical errors, as assessed by an 80 on the students' presentations. In the ABET spreadsheets, this will be called the "Oral Literature Review" outcome.

11. 90% of students will be able to function properly in multidisciplinary teams as assessed by self, team, and faculty evaluations of their performance as being "acceptable" on the end of semester project. In the ABET spreadsheets, this will be called the "multidisciplinary team" outcome.
Florida Institute of Technology

ADDING A NEW MAJOR OR MINOR TO THE CURRICULUM

Please provide the following information when requesting a new major or minor (program or option) to be added to the curriculum. Only new majors, minors and options are assigned a new code and print on the diploma. The code will be assigned by the Office of the Registrar and information emailed to all appropriate personnel.

COLLEGE: Engineering
DELIVERY MODE(S): Classroom (classroom, online)

DEPARTMENT: Chemical Engineering
CAMPUS/SITE(S): Melbourne Campus

PROGRAM TO BE ADDED: □ Major □ Minor □ Option for ______________________ (existing degree program)

NOTE: Only Majors, Minors and Options receive new codes and print on the diploma; use Option for new program name to appear with existing degree name.

☐ Associate of Arts (A.A.) ☐ Associate of Science (A.S.) ☐ Bachelor of Arts (B.A.) ☐ Bachelor of Science (B.S.)
☐ Master of Arts (M.A.) ☐ Master of Science (M.S.)
☐ Master of Business Administration (M.B.A.) ☐ Master of Education (M.Ed.)
☐ Master of Public Administration (M.P.A.)
☐ Master of Science in Aviation (M.S.A.)
☐ Educational Specialist (Ed.S.)
☐ Doctor of Philosophy (Ph.D.)
☐ Doctor of Psychology (Psy.D.)
☐ Graduate Certificate

OTHER ADDITION TO THE CURRICULUM (NOTE: Only Majors, Minors and Options receive new codes and print on the diploma; use Concentration or Specialization if the new program represents less than a full degree curriculum.)

☐ Concentration or ☐ Specialization for __________________________________________ (existing degree program)

PROGRAM TITLE: Restricted to 30 characters, including spaces
Nanoscience/Nanotechnology

TERM TO BE INITIATED: Spring 2014
ADVISOR FOR NEW PROGRAM: Dr. Jim Brenner

(Date program to be initiated must be no sooner than the next term for which registration has not begun)

ROUTING APPROVALS: 1) Department head/program chair and college dean approve and sign form. 2) The associate vice president for institutional compliance reviews and signs form. 3) The executive vice president or his designee approves business plan of the program in terms of financial/viability and impact on the university mission and signs form. 4) Undergraduate Curriculum Committee or Graduate Council approves academics and signs form.
5) The executive vice president or his designee gives final approval of program, signs form and forwards to Office of the Registrar.

1) Department Head/Program Chair

Date: 11/13/13

2) Associate Vice President for Institutional Compliance

Date: 11/18/13

3) Executive Vice President

Date: 11/18/13

4) Chair, Graduate Council

Date: 

OR

5) Chair, Undergraduate Curriculum Committee

Date: 

Executive Vice President

Date: 

REGISTRAR'S USE ONLY

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SOAXREF

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STVMJR

SOACURR

Major Code Assigned

GWVSAX

CIPC Code

Operator Initials/Date

Florida Institute of Technology • Office of the Registrar
150 West University Boulevard, Melbourne, FL 32901-6975 • (321) 674 ext. Fax (321) 674-7827
General Information – ext. 8115, Graduation – ext. 8116, Records and Transcripts – ext. 8117, Registration – ext. 8118

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