



University of Pittsburgh

MEMS Department

Graduate Program in Materials Science and Engineering (MSE)





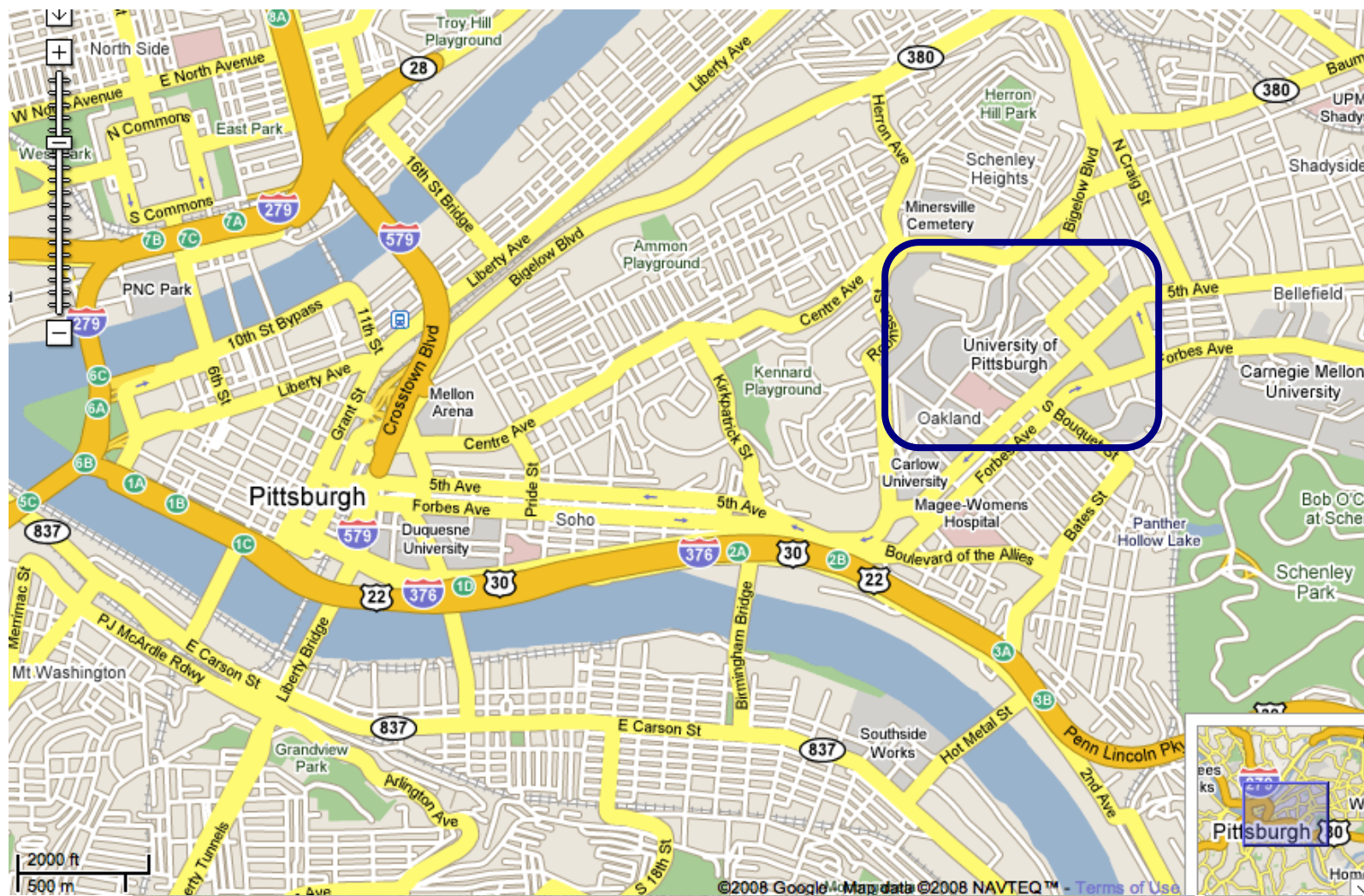
The University of Pittsburgh



- ❖ Founded in 1787
- ❖ Over 32,000 students
- ❖ **Top-20 public research university in USA**
- ❖ Well-known Swanson School of Engineering with six departments and nine programs
- ❖ Global recognition –**37th ~ 116th** in global university rankings (Times Higher-QS World University, Jiao Tong University, Newsweek, etc.)



Our Location ...





It is the mission of the Swanson School of Engineering to produce highly qualified engineers and useful creative research and technology through academic excellence.

Five priorities support this mission - 1. Quality in undergraduate education;
2. Quality in graduate education;
3. Innovative research;
4. Revenue generation and 5. Diversity.



Pittsburgh -
A friendly and beautiful place
to study, work and live.

Oakland -
...cultural center and site of the main
campus of University of Pittsburgh



Pittsburgh Skyline & Golden Triangle at Sunset



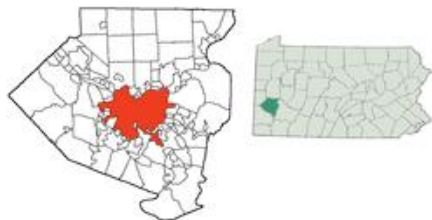
City of Pittsburgh



Seal

Nickname: City of Bridges, Steel City, City of Champions, The 'Burgh, Iron City, Steel Town, The College City, Roboburgh

Motto: Benigno Numine ("With the Benevolent Deity")



Location in Allegheny County, Pennsylvania

Coordinates: 40°26'30"N 80°00'00"W

Country	United States
Commonwealth	Pennsylvania
County	Allegheny
Founded	November 25, 1758
Incorporated	April 22, 1794 (borough) March 18, 1816 (city)

PITTSBURGH --- some data...

Fortune 500 Corporations

Alcoa Inc.

Allegheny Technologies

H.J. Heinz Company

Mellon Financial Corporation

PNC Financial

PPG Industries

WESCO International

US Steel

Fortune 1000 Corporations

Allegheny Energy

American Eagle Outfitters

Consol Energy

Dick's Sporting Goods

Kennametal

Wheeling-Pittsburgh Steel

Other Major Employers include

Alcoa Technical Center

North American HQ's of Bayer, GlaxoSmithKline, Lanxess

Northeast US regional HQ's of Nova Chemicals, FedEx Ground, Ariba, Rand, National City

...84 Lumber, Giant Eagle, Highmark, Rue21, Genco, Mylan Laboratories, GNC, CNX Gas, Westinghouse Electric Corporation, The Bettis Bechtel Laboratory (Home of Naval Nuclear Propulsion Program); DOE National Energy Technology Laboratory, University of Pittsburgh Medical Center... & **University of Pittsburgh**

Government

- Mayor Luke Ravenstahl (D)

Area

- City	58.3 sq mi (151.1 km²)
- Land	55.5 sq mi (143.9 km²)
- Water	2.8 sq mi (7.1 km²)
- Metro	5,343 sq mi (13,839 km²)

Elevation 1,223 ft (372.77 m)

Population (U.S. Census Estimate, 2006)

- City	312,820
- Density	5,636/sq mi (2,174/km²)
- Metro	2,370,776 [1][2]

Time zone EST (UTC-5)

- Summer (DST) EDT (UTC-4)

Area code(s) 412, 724, 878

Website: www.city.pittsburgh.pa.us



Who employs our graduates?



Job Titles:

Materials Engineer

Metallurgist

Glass Scientist

Technical Sales Engineer

Processing Engineer

Polymer Scientist

Project Engineer





Result of merging Departments of Mechanical Engineering
and

Materials Science and Engineering

Since September 2006

- >30 full-time faculty and many adjunct and research faculty;
- All faculty active in research (~ \$8M external support);
- The largest department in the Swanson School of Engineering
- ≥ 600 undergraduates, ~ 200 graduate students
- Graduate Certificate Program in Nuclear Power Engineering, focusing on nuclear reactor operation and safety



Materials Faculty in Tenure and Appointment Streams ~13

- Assoc. Prof. Mostafa Bedewy
- Assoc. Prof. Markus Chmielus
- Prof. Isaac Garcia
- Prof. Brian Gleeson
- Ass. Prof. Zachary Harris
- Assoc. Prof. Tevis Jacobs
- Prof. Jung-Kun Lee
- Assoc. Prof. Ian Nettleship
- Assoc. Prof. Paul Ohodnicki
- Ass. Prof. Tom Piccone
- Prof. Guofeng Wang
- Prof. Jörg Wiezorek
- Assoc. Prof. Wei Xiong

...Expertise and research activities span the *processing/synthesis/fabrication, simulation, structure-property characterizations* of thin films, bulk and particulate systems based on metallic and ceramic materials and their applications in many industry sectors including steels, energy, information technology, and chemical engineering.

... also Adjunct Faculty, Emeritus Faculty, and Research Staff participate in research and educational activities in MSE.

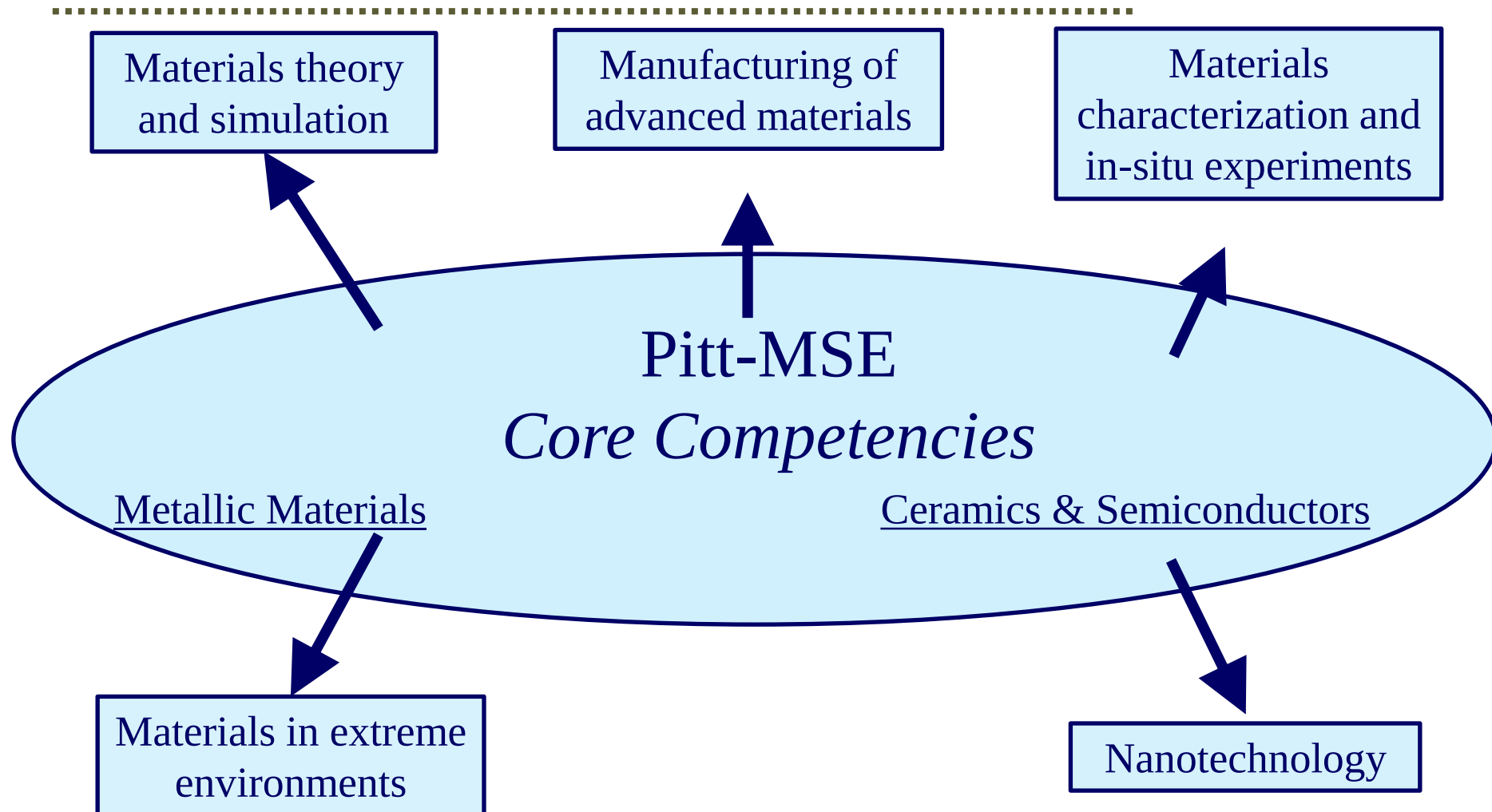


Key Research Competencies of MEMS Department

- Advanced Manufacturing and Design
- Materials for Extreme Conditions
- Biomechanics and Medical Technologies
- Modeling and Simulation
- Energy System Technologies
- Quantitative and In Situ Materials Characterization



MSE Research Foci





Advanced materials increase the efficiency of energy production from fossil fuels

Reducing the environmental impact of power generation from fossil fuels...e.g.

- Advanced High-T materials & coatings to enhance operating temperatures and pressures to increase efficiency (Ultra-Supercritical plants...)
- Carbon capture and sequestration, gas-separation membrane technologies
- High-Strength, corrosion resistant pipe materials

Electric arc furnace – courtesy CMC Steel Texas
Plasma spray coating process – courtesy Praxair Surface Technologies
Drill pipes
Welding process
Coated turbine blades – Siemens press picture



Energy...& Materials

... define and limit human social, technological and political aspirations

New Materials needed for Sustainable, Secure Energy Generation, Distribution, Storage ... and for more efficient utilization!

- *Low Cost Solar Cells*
- *Corrosion-Resistant Alloys for High-T Power Conversion*
- *Light-Weight & Strong Composites for Wind-Turbines*
- *... more energy efficient ground, air*
TRANSPORTATION

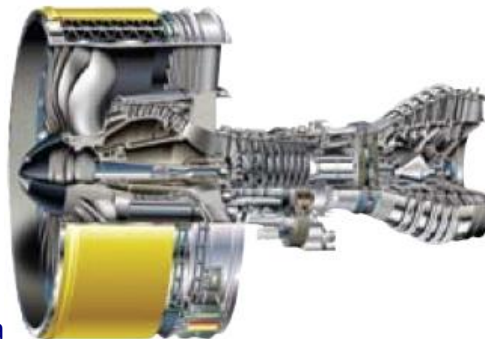




Materials design for superior structural performance (light weight and high strength)

➔ Reducing vehicle mass & changing from petroleum based fuels to alternative (electricity, hydrogen...)fuels;

- **Implement use of Advanced High Strength Steels; Light Metal (Al, Mg, Ti) Alloys; Carbon Composites;**
- **Develop High Performance Magnets; Electrical motors; Batteries for Energy Storage; Fuels Cell Catalysts and Membranes;**



Advanced jet engine – courtesy General Electric Company



First flight of Boeing 787





Faculty and Staff for MSE Program

- Department Chair:
Professor Brian Gleeson
- MSE Graduate Program Coordinator:
Professor Jung-Kun Lee
- MEMS Graduate Administrator:
Ms. Tara Rankin



Graduate Students in MSE

- ❖ 66 graduate students in MSE program currently (this includes new incoming students).
- ❖ MS Students in Materials Science & Engineering – 22 (~2/3 are in a professional track).
- ❖ PhD Students in Materials Science & Engineering – 42 (including 1 PT PhD student)
- ❖ All FT PhD students are fully or partially supported by assistantships as GSR, TA/TF or other fellowships.



Academic Information

❖ Master Degrees (≥ 30 credits):

- 1) Master Degree (Thesis): Typically for Full-Time Students
- 2) Professional Master Degree (Non-Thesis) Part-Time Students

❖ PhD Degree (≥ 72 credits)

Research & Dissertation (Thesis) based degree: Typically for Full-Time Students

Special Notes

➤ Dual Degree MS-MSE / MBA

... offered by Swanson School of Engineering and Katz School of Business

➤ Graduate Nuclear Engineering Certificate Program

- Complete ≥ 5 of the 7 cross-listed courses currently offered as part of NECP (≥ 15 credits)
- NECP fully compatible with MS and PhD in MSE



Compatibility between Programs

=> Interdisciplinary options via numerous
Cross-listed courses in ME/MSE and between MSE
and the Nuclear Engineering Certificate Program, e.g.

ME 2003/MSE 2036 Continuum Mechanics

ME 2010/MSE 2037 Nanomechanics, Materials & Devices

ME 2033 Fracture Mechanics for Product Design / MSE 2032 Failure of
Materials

ME 2022/MSE 2038 Applied Solid Mechanics

ME/MSE2110 Nuclear Materials

ME/MSE2115 Nuclear Plant Heat and Mass Transfer

- **Can obtain MS or PhD MSE & Graduate Certificate in Nuclear Engineering without additional course-load.**



Master Degrees (30 credits):

❖ Professional Master Degree (Non-Thesis)

≥ 30 credits ~ 10 courses;

≤ 9 credits (3 courses) non-MSE technical courses (math, science, engineering);

≤ 6 credits (2 courses) in transfer credits;

❖ Thesis-based Master Degree (Research): typically for full-time

≥ 24 course credits (8 courses) plus 6 thesis credits (MSE2999);

≤ 9 credits (3 courses) non-MSE technical courses (math, science, engineering);

≤ 6 credits (2 courses) in transfer credits;



TIMELINE => MS-Degree Thesis Option (Full-Time):

What?

Choose Advisor

Plan of Study (courses),
consult w. advisor

Begin Research

Complete Independent Research
& Thesis

Apply for Graduation and
Defend Thesis

When?

=> During 1st term;

=> by END of 1st term;

=> During 1st term (no later then 2nd term)

=> During 2nd, 3rd, 4th terms and summer;

=> During Final term (typically 4th or summer);

- The MS-level research must at least be a thesis type report and discussion of independently conducted student research.
- All requirements for thesis based MS degree are typically completed in 2 years (4 terms plus one summer).



Some Logistics for PhD.

Doctoral Students:

- Submit plan of study: (first term)
- Minimum of 72 credits beyond BS level, of which at least **36 course credits** beyond BS level.
- **Minimum Course Requirements (≥ 36 course credits, with ≥ 3.3 GPA)**
 - Materials core courses (six required courses students must take in the first year of enrollment)
 - 1) MSE 2067: Elements of Materials Science and Engineering 1 (Fall),
 - 2) MSE 2003: Structure of Materials (Fall),
 - 3) MSE 2011: Thermodynamics of Materials/Energetics (Fall),
 - 4) MSE 2013: Kinetics in Materials Science (Spring),
 - 5) MSE 2015: Electromagnetic Properties of Materials (Spring),
 - 6) MSE 2030: Mechanical Behavior of Materials (Spring).

Students must score **at least a B (3.0) in each of these six classes**. If a student does not get at least a letter grade of B, the class must be taken a second time. These classes must be successfully completed before the student can apply for admission to PhD Candidacy.



- **Advanced and Technical Elective Courses (≤ 15 credits):**
a group of courses tailored for each student's research and as required technical broadening beyond the MSE focus
- **Courses to address mathematical/numerical skills:**
three (3) credits beyond those required for the materials science and engineering Bachelor of Science degree. This requirement may be waived if it was met in a previous program.
- **PhD Research and Dissertation credits:** each student must have
at least six (6) credits of MSE 3997 (PhD Research);
at least 12 credits of MSE 3999 (PhD Dissertation);

Registration for MSE 3999 is allowed **only after the student has passed the Comprehensive Examination and defended the PhD Proposal**, which qualifies the student for the status of PhD Candidacy.



To advance towards preparation for the PhD dissertation proposal and the Comprehensive exam the student has to

(i) Achieve academic excellence in the six (6) MSE core course sequence (grades of letter grade of B (3.0) or better in each of them, see above)

AND

(ii) Pass the PhD qualifying examination.

➤ **Preliminary Qualifying Exam**

A literature review based mini-proposal in a general topic area suited to each student's anticipated research project.

: Writing a paper + Oral presentation (30 minute presentation) to the committee.

Appropriate topic descriptions should be developed by the advisor and submitted to the Qualifying Exam committee for review in advance.



Written document:

- ✓ The written document must be submitted two (2) weeks prior to the oral presentation. The written document should be no more than 15 pages long (1 inch margins, single spaced, including any necessary figures).
- ✓ Motivational section + Background/Introduction section + Remaining Questions section (describing the major issues that still need to be addressed + a Research Plan (describing experiments and methods of interpretation that can be used to address these open questions) + A list of References

Oral exam:

- ✓ The examining committee consists of 3 faculty, 1 of whom is the coordinator for the entire qualifier process for that year – this person sits on all the committees. The other two members are independent faculty (not to include the advisor).



Timing:

The qualifier will be given **once per year at the end of the spring term – all new PhD degree students must take the exam in the first year**. Special students (less prepared) may delay until the second year if the advisor petitions the graduation committee.

Second attempts:

If the student does not pass the exam, a retake is allowed **if the advisor petitions the graduate committee and commits to continuing to support the student for the 2nd year**. The second attempt can occur the following spring semester or earlier in the fall.



➤ **Comprehensive Exam and Thesis Proposal => Ph.D. CANDIDACY**

➤ **Thesis document preparation and Thesis Defense**

- **Comprehensive Exam** (held at same time as Dissertation Proposal):
 - Part of the PhD Dissertation Proposal Conference
 - Tests students command of specialized knowledge required to successfully complete the proposed doctoral degree research;
 - Completed after courses finished with ≥ 3.3 GPA, typically two to three terms after passing the preliminary qualifying exam;
- **Dissertation Proposal** (held at same time as Comprehensive Exam):
 - Apply for PhD Candidacy (chose committee by one term after passing the Preliminary Qualifying Exam and at least one month prior to proposal meeting);
 - Includes public presentation as a form of Department Seminar;
 - Students may not take MSE 3999 until passing the proposal stage and admission to PhD candidacy;
- **Dissertation Defense:**
 - Typically, at least one term must elapse between successful completion of Dissertation Proposal and the Dissertation Defense;
 - PhD committee meeting to assess quality of scholarship, research and originality;
 - Apply for Graduation in final term;



TIMELINE to a PhD-Degree:

What?

Choose Advisor;

**a) Plan of Study (courses),
consult w. advisor;**

Begin Research

b1) Complete Prelim-Qualifying Exam

**c) Complete PhD Dissertation Proposal
/Comprehensive Exam**

Complete Research and Dissertation

d) Apply for Graduation and Defend Thesis

When?

During 1st term;

by END of 1st term;

During 1st term (no later
then 2nd term)

At the end of 1st year

End 2nd Year or in 3rd Year (recommended)
=> Progress to PhD Candidacy!

Within 4 to 5 years

During Final term



Some Statistics for graduate student performance

- 3 ~ 8 PhDs were produced per year for the last few years.
- All students completed the PhD degree studies **within 4.5 years**. A time of about four years (± 0.5 years) is considered the goal for the average with in the MSE program in MEMS.
- All students had at least two papers accepted by a recognized journal and/or presented at a national conference. In average, their publication performance is equivalent to **3-4 journal papers**.