Proposal for Revising the Undergraduate Physics Curriculum Version 1.0

Department of Physics

April 11, 2023

1 Charge

Our initial charge from Mark Foncannon and FEC Chair Pablo Ortiz (18 May 2022) was as follows:

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On behalf of the Undergraduate Council (UGC) and Chair Katheryn Russ,
the committee reviewed the proposed revisions to the Applied Physics
and Physics major at their recent meeting on April 21. The committee
respectfully requests that program respond to the following items:

1.  UGC requests that the program include and specify the target
 timing of the proposed changes and how many students will be impacted
 per the UGC Policy for Establishment or Revision of Academic Degree
 Programs (see page 5). Please also include the department faculty
 vote on proposed revisions.

2.  Include consultation with Mathematics regarding the addition of
 MAT 27A, MAT 27B and MAT 67.

3.  Include consultation with Atmospheric Science, Chemistry, Computer
 Science and Engineering with addition of these courses.

a.  GEL 50/50L/55/150B

b.  ATM 60/105/115/116/124/158

c.  CHE 105/115/124L/129A/129B/129C

d.  ECS 132/171

e.  EEC 150A/150B

f.  ENG 045
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g. EMS 160/162/162L/164/170/170L/172/172L/174

4. Since Physics courses are important inputs for students in many majors, UGC wondered if there is a plan for faculty to review syllabi of existing courses that may have been updated incrementally over time perhaps outside the formalized process of the dual major revamping, to assure that their syllabi all still are in accordance with the course descriptions in ICMS. Where syllabi have diverged from course descriptions in ICMS, will their descriptions be updated? Any plan to encourage that future updates to course content be systematically reported within the programs so that updates can be made to ICMS if needed would be welcome.

From here:

https://academicaffairs.ucdavis.edu/deans-directors-and-department-chairs-list

I have taken the following lists of department chairs to contact and request a vote:

- Mathematics, Chair Anne Schilling (MAT)
- Earth and Planetary Sciences, Chair Kari Cooper (GEL)
- Land, Air & Water Resources, Chair William Horwath (ATM)
- Chemistry, Chair David Goodin (CHE)
- Computer Science, Chair Dipak Ghosal (ECS)
- Electrical & Computer Engineering, Chair Andre Knoesen (EEC)
- Materials Science & Engineering, Chair Yayoi Takamura (EMS, ENG 45)

2 Boilerplate Email for Department Chairs:

Dear Chair XXX,

We are required by the Undergraduate Council to consult your department regarding proposed changes to our physics undergraduate major requirements. Despite the fact that we expect the impact on your department to be quite minimal, we will explain it here fully, and we hereby request (A) a vote by your department on whether or not to support our changes to the physics major requirements, and (2) a letter of support from your department that includes the outcome of that vote. You can find the UCD requirements for program revisions, including this required consultation, here:
https://ucdavis.box.com/s/v1682jq4dp9sgcrhyr3oog1wp3pa36fd

Our proposal has several aims, the most important of which I consider to be: (1) improving the experience for students that transfer to UCD from a community college in their junior year, (2) increasing the role of computational physics in our program, (3) improving our laboratory offerings, and (4) increasing flexibility for students in schedule and electives. You can find the most recent version of our complete proposal here:

https://github.com/mulhearn/classwork/blob/master/curriculum/curriculum.pdf

However, the full proposal is quite long. Therefore, I have included with this e-mail a much shorter summary of the courses taught in your department which are impacted by this proposal, and our best estimate of the size of that impact.

The approval process for physics has proven long and windy, with many unexpected delays. I would be happy to share my insights with you some day if your department decides to update your own program! As we enter year five of this process for me personally, I am pushing hard to return the proposal to undergradudate council, including your department's letter, as early in the spring quarter as possible. These required consultations are the last item that we need, and I would be very much obliged for your department's rapid response to help our department finish our proposal this year.

Sincerely,
Michael Mulhearn
Professor and Vice Chair for Undergraduate Program and Administration
Department of Physics

3 Math Department

3.1 Changes to MAT courses in all Physics and Applied Physics majors

All of our physics majors (BS in Physics, BS in Applied Physics, and AB in Physics) share a common set of math requirements that cover calculus, linear algebra, and differential equations.

As part of the upgrade of our undergraduate physics curriculum, we have updated the math requirements for all physics majors to include additional options now offered by the math department, specifically linear algebra and differential equations with applications to biology (MAT 27A and MAT 27B) and Modern Linear Algebra (MAT 67). The updated requirements are now:

Table 1: Preparatory Subject Matter (MAT)

Course		Units	Offered	Prereqs	Name
MAT	21A	4	FWS		Differential Calculus
	21B	4	FWS		Integral Calculus
	21C	4	FWS		Partial Derivatives and Series
	21D	4	FWS		Vector Analysis
	one of:				
MAT	22A	3	FWS		Linear Algebra
	27A	3	FWS		Linear Algebra
	67	4	FWS		Mod. Linear Algebra
MAT	22B	3	FWS		Differential Equations
	or				
MAT	27B	3	FWS		Differential Equations

3.2 Expected impact of these changes on the Math department

In principle, these changes impact all of our 250 physics majors, with an average annual throughput in any math class of approximately 50. However, the actual impact will be much smaller. We have already been accepting these courses as equivalent on a case by case basis whenever requested by a student. These changes simply advertise this equivalence. We expect that this change will have very little impact: even if a surprising large 10% of physics majors decide to use an alternative class, the impact to the math department would be about five students per year per course.

We also understand this update to be fully consistent with the math departments intentions in offering these alternative courses. Please note that **the inclusion of MAT 27A and 27B was specifically requested by the math department**, as shown in the enclosed letter.

3.3 Update to math prerequisites of physics courses

As part of our curriculum overhaul, we have also updated all of the math prerequisites to be consistent with the equivalencies used by the math department, as shown here:

Table 2: Math prerequisite for lower division courses related to physics courses. Where indicated, course grades are the minimum accepted to meet prerequisites. **The prerequisites for the math courses are set by the math department and are only reported here**, including some simplifications. Where possible, math prerequisites for physics courses will adopt the same choices made by the math department with respect to equivalent math coursework.

Course		Math Prereqs (Minimum Grade)	Name
MAT	16A		Short Calc.
	16B	21A/21AH/17A/16A(C-)	Short Calc.
	16C	21B/21BH/17B/16B(C-)	Short Calc.
	17A		Calc (Bio&Med)
	17B	21A/21AH/17A/16A(C-)	Calc (Bio&Med)
	17C	17B(C-)	Calc (Bio&Med)
	21A		Calculus
	21B	21A/21AH(C-) or 17A(B)	Calculus
	21C	21B/21BH/17C/16C(C-) or 17B(B)	Calculus
	21D	21C/21CH(C-) or 17C(B)	Calculus
	22A	21C/21CH/17C/16C(C-)	Linear Algebra
	22B	67/22A(C-)	Diff. Eqs.
	27A	21C/21CH/17C(C-)	Linear Algebra w/ App. Bio.
	27B	27A/22A(C-)	Diff. Eqs. w/ App. Bio.
	67	21C/21CH(C-)	Mod. Lin. Alg.
PHY	9A	21B/21BH/17C/16C(C-) or 17B(B)	Class. Physics
	9B	21C/21CH(C-) or 17C(B)	Class. Physics
	9C	21D(C-)	Class. Physics
	9D	22A(C-) or 27A(C-) or 67(C-) ‖22B or ‖27B	Class. Physics
PHY	9HA	‖21B/‖21BH	Hon. Physics
	9HB	21B/21BH(C-)	Hon. Physics
	9HC	21C/21CH	Hon. Physics
	9HD	21D	Hon. Physics
PHY	45	‖22B or ‖27B	Computational Physics

As physics majors are required to take the MAT 21 sequence, these changes only impact non-physics majors taking the PHY 9 sequence. Therefore, **these changes are outside the scope of the vote on the proposed changes to physics majors**. They have been included here only for completeness, and we certainly welcome any comments on the appropriateness of these changes.

4 Earth and Planetary Sciences (GEL)

Chair Kari Cooper

4.1 No changes to GEL courses for Physics AB and BS majors

There are no changes to Geology coursework to the Physics majors (AB and BS) including the Astrophysics specialization. Astrophysics majors will still be required to take GEL 163 in the new program.

4.2 Changes to GEL courses for Applied Physics majors

The proposed physics curriculum includes changes to the Applied Physics major with specializations in Atmospheric Physics, Physical Oceanography, and Geological Physics related to GEL coursework, as detailed in Tables 3-5. All three of these majors were designed before significant changes to the prerequisite structure of GEL courses.

In the proposed Atmospheric Physics major, GEL 50 is required (was only recommended). In the current requirements, GEL 150A was a required course, but due to the increased prerequisite requirements, this is no longer possible. Instead, GEL 116N, 150A, and 150B are listed along with PHY and ATM coursework as possible electives in the proposed requirements.

In the current requirements for the Physical Oceanography major, GEL 116N and 150A were required. Due to prerequisites, this now implicitly requires GEL 50 as well, which pushes this major based the unit cap guidelines for required coursework. In the proposed major, GEL 50, 55, 116N, and 150A are all required courses. Students may also include 150A as one of two electives that include other choices from PHY and ATM courses.

In the current requirements for the Geological Physics major, GEL 161 and 162 are required. Due to prerequisites, this now implicitly requires GEL 50 as well, which pushes this major based the unit cap guidelines for required coursework. In the proposed major, GEL 50 and 50L are all required courses. Students can choose five electives from GEL 116N, 146, 150A, 150B, 161, 162, 163, and other PHY and ATM courses. They are required to select at least two from GEL 161,162, and 163.

To summarize, all three of these specializations have been changed to properly account for prerequisite coursework for required courses and to afford students additional choices for elective coursework in PHY, ATM, and GEL.

4.3 Expected impact of these changes on the Earth and Planetary Sciences department

Blah blah blah...

Table 3: Required GEL Coursework for Atmospheric Physics

*: recommended, #: not offered every year, ‖: concurrently.

Course		Units	Offered	Prereqs	Name
GEL	50	3	FWS		Physical Geology
	Choose two of				
PHY	105B	4			
	105C	4	#		Continuum Mechanics
GEL	116N	3	S	GEL 50	Oceanography
	150A	4	S#	GEL 116N,55	Physical and Chemical Oceanography
	150B	3	W	GEL 50	Geological Oceanography
ATM	124	3	F	ATM 60	Meteorological Instruments & Observations
	128	4	W	ATM 60	Radiation and Satellite Meteorology
	158	4	S	ATM 121A	Boundary-Layer Meteorology

Table 4: Required GEL coursework for Physical Oceanography

*: recommended, #: not offered every year, ‖: concurrently.

Course		Units	Offered	Prereqs	Name
GEL	50	3	FWS		Physical Geology
	55	3	F	CHE 2A	Intro. to Geochemistry
Course		Units	Offered	Prereqs	Name
GEL	116N	3	S	GEL 50	Oceanography
	150A	4	S#	GEL 116N,55	Physical and Chemical Oceanography
	Choose two of				
PHY	105B	4			
	105C	4	S#		Continuum Mechanics
ATM	115	3	S	ATM 60	Hydroclimatology
	116	3	F		Modern Climate Change
	120	4	F	ATM 60‖	Atmos. Thermo. and Cloud Physics
GEL	150B	3	W	GEL 50	Geological Oceanography

Table 5: Required GEL coursework for Geological Physics

*: recommended, #: not offered every year, ||: concurrently.

Course		Units	Offered	Prereqs	Name
GEL	50	3	FWS		Physical Geology
	50L	2			Physical Geology Laboratory
	Choose five of				
PHY	105B	4			
	105C	4			Continuum Mechanics
ATM	120	4	F	ATM 60	Atmos. Thermodynamics & Cloud Phys.
	121A	4	F	ATM 120	Atmospheric Dynamics
	121B	4	W	ATM 121A	Atmospheric Dynamics
GEL	116N	3			Oceanography
	146	3			Radiogenic Isotope Geochem. & Cosmochem.
	150A	4	S#	GEL 116N,55	Physical and Chemical Oceanography
	150B	3	W	GEL 50	Geological Oceanography
	incl at least two:				
GEL	161	3	S#	GEL 50	Geophysical Field Methods
	162	3	W#	GEL 50	Geophysics of the Solid Earth
	163	3	F#	GEL 50	Planetary Geology

To summarize, all three of these specializations have been changed to properly account for prerequisite coursework for required courses and to afford students additional choices for elective coursework in PHY, ATM, and GEL.

5 Land, Air & Water Resources

Chair: William Horwath (ATM)

5.1 No changes to ATM courses for Physics AB and BS majors

There are no changes to Geology coursework to the Physics majors (AB and BS).

5.2 Changes to ATM courses for Applied Physics majors

The proposed physics curriculum includes changes to the Applied Physics major with specializations in Atmospheric Physics, Physical Oceanography, and Geological Physics related to ATM courework, as detailed in Tables 6-8.

In the current requirements for the Atmospheric Physics specialization, ATM 120,121A, and 121B are required courses. Due to prerequisites, this now implicitly requires ATM 60 as well, which pushes this major past the unit cap for required coureswork. In the proposed requirements, ATM 60,120,121A and 121B are now all explicitly required while the major still remains below the unit cap. In the current requirements, ATM 128 is a possible elective. In the proposed requirements, ATM 124,128, and 158 are included amongst PHY and GEL courses as possible electives.

In the current requirements for the Physical Oceanography specialization, ATM 120 is a required course. This implicitly requires ATM 60, which pushes this major past the unit cap for required coursework. In the proposed requirements, ATM 60 is a recommended course, and ATM 115,116, and 120 are included as possible electives alongside PHY and GEL courses.

In the current requirements for the Geophysics major, students must choose one course from ATM 120,121A, and 121B. Due to prequisites, this effectively requires students to take both ATM 60 and 120, pushing this major past the unit cap for required coursework. In the proposed requirements, ATM 60 is required and students choose five electives from ATM 120,121A, 121B, and other courses in GEL and PHY.

To summarize, all three of these specializations have been changed to properly account for prerequisite coursework for required courses and to afford students additional choices for elective coursework in PHY, ATM, and GEL.

5.3 Expected impact of these changes on the Land, Air & Water Resources department

Blah blah blah.

Table 6: Required ATM coursework for Atmospheric Physics

*: recommended, #: not offered every year, ‖: concurrently.

Course		Units	Offered	Prereqs	Name
ATM	60	4	F		Intro. to Atmospheric Sci.
	120	4	F	ATM 60‖	Atmos. Thermo. and Cloud Physics
	121A	4	W	ATM 120	Atmospheric Dynamics
	121B	4	S	ATM 121A	Atmospheric Dynamics
	Choose two of				
PHY	105B	4			
	105C	4	#		Continuum Mechanics
GEL	116N	3	S	GEL 50	Oceanography
	150A	4	S#	GEL 116N,55	Physical and Chemical Oceanography
	150B	3	W	GEL 50	Geological Oceanography
ATM	124	3	F	ATM 60	Meteorological Instruments & Observations
	128	4	W	ATM 60	Radiation and Satellite Meteorology
	158	4	S	ATM 121A	Boundary-Layer Meteorology

Table 7: Required ATM coursework for Physical Oceanography

*: recommended, #: not offered every year, ‖: concurrently.

Course		Units	Offered	Prereqs	Name
ATM	60*	4	F		Intro. to Atmospheric Sci.
	Choose two of				
PHY	105B	4			
	105C	4	S#		Continuum Mechanics
ATM	115	3	S	ATM 60	Hydroclimatology
	116	3	F		Modern Climate Change
	120	4	F	ATM 60‖	Atmos. Thermo. and Cloud Physics
GEL	150B	3	W	GEL 50	Geological Oceanography

Table 8: Required ATM coursework Geological Physics

*: recommended, #: not offered every year, ‖: concurrently.

Course		Units	Offered	Prereqs	Name
ATM	60	4	F		Intro. to Atmospheric Sci.
	Choose five of				
PHY	105B	4			
	105C	4			Continuum Mechanics
ATM	120	4	F	ATM 60	Atmospheric Thermo. & Cloud Phys.
	121A	4	F	ATM 120	Atmospheric Dynamics
	121B	4	W	ATM 121A	Atmospheric Dynamics
GEL	116N	3			Oceanography
	146	3			Radiogenic Isotope Geochem. & Cosmochem.
	150A	4	S#	GEL 116N,55	Physical and Chemical Oceanography
	150B	3	W	GEL 50	Geological Oceanography
	incl at least two:				
GEL	161	3	S#	GEL 50	Geophysical Field Methods
	162	3	W#	GEL 50	Geophysics of the Solid Earth
	163	3	F#	GEL 50	Planetary Geology

6 Chemistry

Chair: David Goodin (CHE)

6.1 No changes to CHE courses for Physics AB and BS majors

There are no changes to Chemistry coursework to the Physics majors (AB and BS).

6.2 Changes to CHE courses for Applied Physics majors

The proposed physics curriculum includes changes to the Applied Physics major with specializations in Physical Oceanography and Chemical Physics.

In the proposed requirements for the Physical Oceanography sepcialization, CHE 2A is now a required course. This is to satisfy the prequisite for GEL 55 which is also a required course for this major.

The current requirements for the Chemical Physics specialization include CHE 2A,2B,2C and 124A as required courses. There are no chemistry electives, only a long list of recommended upper division chemistry courses. This is because both Chemistry and Physics are highly hierachical, and it is time consuming to complete the prerequisites for upper division coursework in both subjects. In the proposed requirements, CHE 2A,2B,2C and 124A are still required. However, students are also given the flexibility to take the sequence CHE 110A,110B,110C, and 128A in the place of related coursework in physics. In additional, they may satisfy their lab requirements with coursework in either physics or CHE 105,115,124L,129A,129B,129C.

These changes to the CHE requirements for the Chemical Physics specialization are intended to encourage students to explore more chemistry coursework, making this a more compelling and interesting major.

6.3 Expected impact of these changes on the Chemistry department

Because CHE 2A was already implicitly required for the Physical Oceanography specialization, making this requirement explicit should have a negligible impact on the Chemistry department.

We have had very low enrollment in the Chemical Physics major, perhaps because the current requirements are so uncompelling (Physics BS plus CHE 2 and 124A). While we hope the revised requirements will create more interest, it is unlikely that these changes would impact enrollment in chemistry by more than four students per year.

Table 9: Required CHE coursework for Physical Oceanography

*: recommended, #: not offered every year, ‖: concurrently.

Course		Units	Offered	Prereqs	Name
CHE	2A	5	FW		

Table 10: Required CHE coursework for Chemical Physics

*: recommended, #: not offered every year, ‖: concurrently.

Course		Units	Offered	Prereqs	Name
CHE	2A	5	FW		General Chemistry
	2B	5	WS		General Chemistry
	2C	5	FS		General Chemistry
CHE	124A	3			Inorganic Chemistry
PHY	115A	4			
	115B	4			
	112	4			
	140A	4			
	140B*	4			
	Or:				
CHE	110A	4			Physical Chemistry: Intro to QM
	110B	4			Physical Chemistry: Atoms and Molecules
	110C	4			Physical Chemistry: Thermodynamics
	128A	4			
	128B*	4			
PHY	115A*	4			
	112*	4			
	6 or more units:				
PHY	122A/B	4			
	117	4			
	118	4			
CHE	105	4			Analytical & Physical Chemical Methods
	115	4			Instrumental Analysis
	124L	2			Laboratory Methods in Inorganic Chemistry
	129A	2			Organic Chemistry Laboratory
	129B	2			Organic Chemistry Laboratory
	129C	2			Organic Chemistry Laboratory

7 Computer Science

Chair: Dipak Ghosal (ECS)

7.1 No changes to ECS courses for Physics AB and BS majors

There are no changes to Computer Science coursework to the Physics majors (AB and BS).

7.2 Changes to ECS courses for Applied Physics majors

The proposed physics curriculum includes changes to the Applied Physics major with specialization in Computational Physics that impact ECS coursework, as detailed in Table reftbl:ecscomputational.

In both the current and proposed major, students are required to take ECS 36ABC and 122A. In the proposed requirements, students choose at least one elective from ECS 120,122B,132, and 171 (in the current requirements, students choose from ECS 120, 122B, and 130).

It is worth noting that a major objective of the overall curriculum update is to increase the role of computational physics in training our students. The specialization in Computational Physics benefits from these improvements, including the new course PHY 40 (Introduction to Computational Physics) and new one unit computational physics lab courses (110L, 112L, and 115L). Computational physics students are expected to satisfy the prerequisites for 110L,112L, and 115L via ECS 36ABC, whereas other majors satisfy this requirement via the less ambitious (computationally) PHY 45 (Computational Physics).

In summary, the changes to the Computational Physics specialization are aimed at providing flexibility for students to study programming and computational techniques outside of physics, and then bring those skills back to the physics department to apply them specifically to physics problems.

7.3 Expected impact of these changes on the department

7.4 Additional Request: Pass 1 access to ECS 36ABC for Applied Physics majors

Table 11: Required ECS coursework in Computational Physics

*: recommended, #: not offered every year, ‖: concurrently.

Course		Units	Offered	Prereqs	Name
ECS	36A	4	FWS		Programming and Problem Solving
	36B	4	FWS		Software Dev. and OOP in C++
	36C	4	FWS		Data Structures, Algorithms, and Programming
	122A	4	FWS		Algorithm Design & Analysis
	Choose one of				
ECS	120	4	FWS		Theory of Computation
	122B	4	WS		Algorithm Design & Analysis
	132	4	FWS		Probability & Stat Modeling
	171	4	F		Machine Learning

8 Electrical & Computer Engineering

Chair: Andre Knoesen (EEC)

8.1 No changes to EEC courses for Physics AB and BS majors

There are no changes to Electrical & Computer Engineering coursework to the Physics majors (AB and BS).

8.2 Changes to EEC courses and ENG 17 for Applied Physics majors

The proposed physics curriculum includes changes to the Applied Physics major with specializations in Physical Electronics that impact ENG and EEC coursework, as detailed in Table reftbl:ecselectronics.

In both the current and proposed requirements, students are required to take EEC 17 and 100. In the proposed requirements, students choose four elective courses from EEC 110A, 110B, 140A, 140B, 150A, and 150B. (In the curent requirements, 150A and 150B are not included)

8.3 Expected impact of these changes on the Electrical & Computer Engineering department

We expect the impact of these changes to be minimal. In particular, we have been accepting EEC 150A and 150B as electives on a case-by-case basis when requested by students. These changes merely make this flexibility more explicit.

Table 12: Required EEC coursework for Physical Electronics

Units: 8 units. *: recommended, #: not offered every year, ||: concurrently.

Course		Units	Offered	Prereqs	Name
ENG	17	4	FWS		Circuits I
EEC	100	4	FW		Circuits II
	Choose four of				
EEC	110A	4	WS		Electronic Circuits I
	110B	4	S		Electronic Circuits II
	140A	4	FW		Principles of Device Physics I
	140B	4	S		Principles of Device Physics II
	150A	4	WS		Intro. to Signals & Systems I
	150B	4	F		Intro. to Signals & Systems II

9 Materials Science & Engineering

Chair: Yayoi Takamura (EMS, ENG 45)

9.1 No changes to EMS and ENG courses for Physics AB and BS majors

There are no changes to Materials Science & Engineering coursework to the Physics majors (AB and BS).

9.2 Changes to EMS courses and ENG 45 for Applied Physics majors

The proposed physics curriculum includes changes to the Applied Physics major with specializations in Materials Physics that impact ENG and EMS coursework, as detailed in Table 13.

In the current requirements, Materials Physics students are required to take EMS 174 and 180, which implicitly requires them to take ENG 45 as well, pushing this degree past the unit cap on required coursework. In the proposed requirements, students are required to take ENG 45, and choose two electives from EMS 162, 160+164, 170, 172, 174, and 180. Furthermore, they may satisfy their lab work requirements from several choices within both PHY and EMS.

9.3 Expected impact of these changes on the Materials Science & Engineering department

Table 13: Required ENG and EMS coursework for Materials Physics

*: recommended, #: not offered every year, ‖: concurrently.

Course		Units	Offered	Prereqs	Name
ENG	45	4	FWS		Properties of Materials
	Choose two of				
EMS	162	4	W		Structure & Characterization
	160+164	7	F+W		Thermo+Kinetics
	170	4	S		Sustainable Energy
	172	4	F		Smart Materials
	174	4	S		Mech. Behavior of Materials
	180	4	F		Materials in Eng. Design
	Choose two of				
PHY	122A/B	4			
	117	4			
	118	4			
	at most one of				
EMS	162L	3	W		Structure & Characterization Lab
	170L	3	S		Sustainable Energy Lab
	172L	3	F		Smart Materials Lab
	174L	3	S		Mech. Behavior of Materials Lab