

**MEMS SURVEY COURSE 569**  
**Spring 2020 from TUES. 21 Jan to Thur. 7 May**

**3 Credits**  
**SEE CSU 2020 Calendar**

**“How little we know, how eager we are to learn, BUT COME ON A 19-page SYLLABUS???”**

**YES, as all aspects of the course are covered herein**

ALL OF THIS MATERIAL IS TENTATIVE AND SUBJECT TO CHANGE. Changes occur in 569 via CLASS ANNOUNCEMENTS and 569 memos sent to all students throughout THE SEMESTER, which supersede this draft syllabus document.

**Instructor:** Prof. George Collins, Email: [gcollins@engr.colostate.edu](mailto:gcollins@engr.colostate.edu)

**Class Time:** **Tuesday and Thursday 5:30 to 6:45**.in room  
( math wing) E 104

**NO CLASS Thur. 12 March** before spring break due to anticipated class time overruns during critique talks by hours.

## **Grading Summary:**

- 1. HW Assignments: 10%**
  - 2. Talk / Paper # 1: 20 %**
  - 3. Talk / Paper #2: 40%**
  - 4. Exam #1 on second order LINEAR mechanical and electrical systems commonalities: 10%**
  - 5. Pop Quizzes: 20%**
- THIS TOTALS 100%**

**10 % extra credit opportunity described later**

**For both STUDENT talks** the format is to have a critique PPT talk first, where I point out short comings, and then week later send the final PPT and word documents to me directly by email attachment. Do not send revised talk material to either CANVAS or to the grader.

# OVERVIEW of 569 Topics

First 8 lectures are an Introduction to 569 with an emphasis on a mile wide and an inch deep review of fitness and medical wearable MEMS. The most important of which will be covered in depth in lectures 9-45 which are an inch wide and a mile deep coverage on MEMS sensors and actuators.

Following is a detailed description of everything you want to know about the 569 course itself. It tries to anticipate most of your questions and beyond. After the “mile wide and inch deep” introduction to bio MEMS in weeks 1 to 4, we then can appreciate in a shallow way, the wide scope of MEMS applications. The in depth section of 569 follows.

After group talk # 1 in 569, I then drill down in depth on commercial MEMS systems of sensors, DSP, ADC and wireless com. This occurs till the end of the course, with MEMS commercial sensor and actuator applications including but not limited to the 7 below:

1. **MEMS based 3-d accelerometers and 3-d gyroscopes on a Chip**  
Ultra books and tablet computers both need MEMS acceleration and gyro sensors for swipe and tap commands. **MEMS Accelerometers and Gyros for Cell Phone Applications including:**
  - a. **Swipe and tap as well as screen orientation of the phone commands**
  - b. **Inside building navigation aids when away from GPS signals.**
2. **Static MEMS Pressure sensors and capacitive/ resistive touch screens for cell phones and tablets are presented as well as for body blood pressure sensors, located all on a chip. Dynamic MEMS pressure sensors sensitive in the the audio frequency range are termed microphones or speakers and are found on ALL cell phones in quantities from 1 to 6 for increases signal to noise for SIRI, Alexa, Cottina, etc voice activated cell phone apps. Stereo microphones/speakers with on board signal processing also appear on SMART SPEAKERS.**
3. **MEMS Ink jet heads for printing 2D patterns on paper but more importantly 2 ½ D printing od electronic antenna and interconnect traces on PCB's. Next we cover the 3D printers of mechanical parts and even 3D tissue printing of artificial 3-d layers of cells for organs (yikes simple organs such as bladders, noses and ears are already being made and sold)**

4. **MEMS based tuning of RF antennas for transceivers via MEMS based movable plate RF capacitors located in matching networks.**
5. **MEMS high Q filters (e.g. FBARS or film bulk acoustic resonators) that are replacing quartz crystal filters and oscillators in electronics circuits such as receivers Rx/ receivers Rx. An example is the FBAR filters with  $Q' > 1000$  at several GHz for receive and transmit electronics for 3G,4G and 5 G technology. One type of low cost High Q mechanical GHz filters for cell phone transceivers 3G to 5G on cell phones are called FBARS and are made in Fort Collins Broadcom facility**
6. **MEMS based micro optics that allows a projector to be shrunk so it can fit in cell phones ("Pico projector") and cameras to display images or videos on a remote screen. Optical MEMS like HD projection displays are now located TODAY in top end cell phones (Samsung Galaxy) and cameras (Nikon Cool Pix). For projecting larger screen visuals like movies, PPT slides or live TV there are larger projection devices. However, all employ digital controlled micro mirror arrays of over 2 million movable mirrors.**
7. **Human Genome DNA analysis on a MEMS microfluidics microchip that allows your complete genome or the genome of a bacteria/virus/cancer in your body for under \$1000. Simple DNA tests from "National Geographic", or "23 and me" sell for well under \$100. Some home tests are now sold in pharmacies. Again this is meant for group talk # 2 extending your treatment of Microfluidic Medical applications in talk #1.**

**We will always find more function for less cost by employing MEMS technology that includes sensors, signal processing and often wireless I/O to connect the sensor to the local network or to the cloud. This brings up the four letter word "cost". That is these chip based MEMS systems cost only 1/1000 of their large scale counterparts, yet have equal or improved performance. As a consequence this commercial field is growing at over 35% per year. With smart cell phones, smart watches and smart speakers that are voice controlled are replacing keyboard activated tablets and PC's.**

The goal of this overly detailed memo is to let students know in a clear, plain and intelligible manner what is expected in 569 as regards GROUP and individual grading, due dates of assignments and the importance of the two GROUP talks and WORD papers during the semester. This is SURVEY course for MEMS (Micro electromechanical systems and microfluidics. As such it is broad in sweep the first 5 weeks with in depth portions in the second half of the course covering in depth 7 commercial MEMS systems.

## Instructor Philosophy

**ECE Students are the most important people at CSU.**

**Students are not dependent on faculty rather faculty are dependent on them.**

**Office visits are not an interruption of our work.**

**They are the purpose of being at CSU.**

**Students are doing us a favor when they come to our office.**

**We are not doing them a favor by serving them.**

**Students are part of our business, not outsiders.**

**Not just a CSU ID number.**

**They are flesh and blood human beings with feelings and emotions.**

**Students come to us with their needs and wants.**

**It is our job to address them with courteous and attentive treatment.**

**Students are the life blood of this and every university.**

**Without them we would close our doors.**

**DON'T EVER FORGET THIS!**

**SEE: <http://www.engr.colostate.edu/ECE569>**

In short the MEMS course starts with a wide horizontal line of knowledge “**an inch deep and miles wide**” and then proceeds to a vertical drill down very deep into 7 MEMS commercial topics “**an inch wide and a mile deep**”.

**Please forgive this lengthy syllabus, schedule and grading missive, but there are lots of issues to cover in a survey course. To keep it all clear and fresh, I will send out a weekly memo usually a week in advance detailing:**

**Last week's efforts**

**This week's efforts and what's due the coming week (e.g. Pop Quiz)**

**Next week's efforts and due dates for all new assignments**

**In addition one can earn more points as follows:**

**Class participation not attendance: 3 % for active contributions. Do not be a potted plant in class.**

**Optional Group Extra credit up to 7% on the topic of your choice in MEMS. This is a semester long OPTIONAL individual Ex credit. It is due the first day of finals week 11 May 2020. Be through in your extra credit**

**Example some Topics to cover if you choose RF MEMS for individual extra credit include:**

- a. RF MEMS switches for low insertion loss, wide bandwidth and high isolation even up to 5G millimeter waves and low adjacent channel cross talk
- b. MEMS variable capacitors and inductors for variable impedance matching/tuners as well as  
Analog phase shifters
- c. Reconfigurable MEMS RF filters and oscillators (think FBARS and YIG devices) with high stop band rejection and low passband loss. 5 G wireless transceivers need to quickly change frequencies among available bands
- d. Miniature antennas and antenna arrays for focused beam steering
- e. Use class lectures and manufactures websites (like Wi Spry, Analog Devices, TI, etc.)

**Below I break out what I grade in 569 vs what the grader grades.** 569 Grading by Collins Summary: Both Talks and associated PPT and WORD due one week after your group presents in class for a critique secession. Individual Semester long extra credit due in a MEMS topic of your choice due 11 MAY. Send all as email attachments ONLY to: [gcollins@engr.colostate.edu](mailto:gcollins@engr.colostate.edu) not to CANVAS or the grader

**Grader grades all else which is to be done as a group assignment and submitted to CANVAS for the grader but NOT to me.**

1. **STUDENTS 562 Critique** Talk # 1: 20 % **TALK #1 occurs from** from **18 to 27 Feb,**.

The format is to have a critique PPT talk first, where I point out short comings, and then week later send the final PPT and word to me directly by email attachment. Do not send to CANVAS or to the grader.

**COMMON Talk # 1 topic is Employing Body Area Networks of MEMS wireless sensors and cell phone/ watch or body attached data collectors for sports, medical or enhanced personal awareness. Go to Apple's website to learn about the new Apple watch that combines both fitness and health monitoring. This common topic gives you a chance to see talks by your fellow students both good and bad and learn from each.**

**Send directly REVISED WORD and PPT to Collins by email attachment one week after class presentation. Do not send to CANVAS.**

## Grading Talk # 1

**Individual Portions of the PPT Presentation for talk # 1 is graded as follows out of 15 total:**

1. TECHNICAL ACCURACY 9/15
2. PPT Slide ORGANIZATION 3/5
3. CLARITY OF MATERIAL-SHORT LIST OF TOPICS, IN DEPTH COVERAGE, BETTER THAN MANY TOPICS VERY SHALLOW DOVERAGE 1/15
4. PROPER SPELLING, GRAMMAR, REFERENCES 1/15
5. FOLLOWING THE MEMOS ON TOPICS TO BE COVERED 1/15

**GROUP WORD PAPER FOR BOTH TALK #1 and Talk # 2 IS GRADED OUT OF 5 AS FOLLOWS:**

1. TECHNICAL ACCURACY 3/5
2. PAPER ORGANIZATION 1/5
3. CLARITY OF MATERIAL-SHORT LIST OF TOPICS IN DEPTH COVERAGE BETTER THAN MANY TOPICS VERY SHALLOW DOVERAGE .5/5
4. FOLLOWING THE MEMOS ON TOPICS TO BE COVERED .5/5

**STUDENTS 569 Critique Talk # 2 (14 -23 April)** for two weeks

Any topic in MEMS is acceptable for each individual student. The format is to have a critique PPT talk first, where I point out short comings, and then week later send the final PPT and word to me directly by email attachment. Do not send to CANVAS or to the grader.

**PPT Presentation for talk # 2 is graded as follows out of 35 total:**

1. TECHNICAL ACCURACY 20/35
2. PPT Slide ORGANIZATION 7/ 35
3. CLARITY OF MATERIAL-SHORT LIST OF TOPICS IN DEPTH COVERAGE BETTER THAN MANY TOPICS VERY SHALLOW DOVERAGE 4/ 35
4. PROPER SPELLING GRAMMAR REFERENCES 2/25
5. FOLLOWING THE MEMOS ON TOPICS TO BE COVERED 2/25

**GROUP WORD PAPER FOR Talk # 2 IS GRADED OUT OF 5 AS FOLLOWS:**

1. TECHNICAL ACCURACY 2/5
2. PAPER ORGANIZATION 1/5

3. CLARITY OF MATERIAL-SHORT LIST OF TOPICS IN DEPTH  
COVERAGE BETTER THAN MANY TOPICS VERY SHALLOW  
DOVERAGE 1/5
4. PROPER SPELLING GRAMMAR REFERENCES .5/5
5. FOLLOWING THE MEMOS ON TOPICS TO BE COVERED 0.5/5

## HOME WORK AND POP QUIZZES

Send to grader via CANVAS group assignments such as : EXAM I, ALL Pop Quizzes, ALL HW. **Only 5/ 10 HW and Pop Quizzes are required:**  
**Send all HW solutions to grader via CANVAS:**

Send to Collins by email attachment three items and NOT to CANVAS or the grader: ALL GROUP corrected talks one week after in class delivery, and INDIVIDUAL semester long ex credit

### GRADER: TBA

The HW assignments below are DIFFERENT for graduate students (problems chosen are harder) than undergraduates (problems chosen are easier). Again Homework Assignments below are not all required –**DO ONLY 5/ 9** not all nine. Finally, the HW is to test your reading and comprehension of the text ONLY.

CANVAS Assignments	Tentative CANVAS Publish Date Date	CANVAS Due date
HW1	Tues. 21 Jan	Tues. 28Jan
Group Take home Exam 1	Tues. 21Jan	Thur. 13 Feb
Pop quiz 1and HW #1	Tues. 21 Jan	Both due Thur. 30 Jan
HW2	Tues. 28 Jan	Tues. 4 Feb

Pop quiz 2	Tues. 28 Jan	Thur. 6 Feb
HW3	Tues. 4 Feb	Tues. 11 Feb
Pop quiz 3	Tues. 4 Feb	Thur. 13 Feb
HW4	Tues. 11 Feb	Tues. 18 Feb
Pop quiz 4	Tues. 11 Feb	Thur. 20 Feb
HW5	Tues. 3 March	Tues. 10 March
Pop quiz 5	Tues. 3 March	Thur. 12 March No class 12 March but PQ due

**That ends required HW and Pop Quizzes**

**NO 569 CLASS Thur. 12 March** before spring break.

**Send directly to Collins by email attachment corrected PPT slides and Word papers one week after class presentations. Do NOT send via CANVAS or to the grader**

**I will try in class to cover topics beyond the old text:**

1. What we did last week
2. What prior assignment is due that coming week (e.g. Pop Quiz, Chapter HW, upcoming talks etc.). In general, the Pop Quiz is due the following week Thur. that it was assigned, whereas the HW is due, the following week Tues.
3. I will also detail what's newly assigned for that coming week and future due dates as well for all new assignments. Due dates for exams and HW are given below in the syllabus.

**The role of MEMS in the IoT (Internet of things) is emphasized where each MEMS sensor has an IP address. For example, MEMS personal sensor networks equipped with wireless communication for very local body area networks for fitness or health. Illustrative health sensing data include MEMS to monitor: your heart beat and any irregularities, blood oxygen, steps taken each day, etc. Similar IoT networks of MEMS sensors for office building wide area lighting HVAC networks as well as smart roads for traffic control. All employ MEMS sensors for SCADA data collection, which is analyzed on the cloud by IT (information technology), operational**



technology (OT) algorithms/ AI programs to collate and parse the data to achieve: more system productivity or efficiency, less system operation costs, pro-active system component maintenance to reduce system down time and increase system reliability as well as in the future allow real-time decision making by computers.

## RESOURCES AVAILABLE

TEXT, web notes, You Tube videos and websites to learn from

**Required Text** – “Microsystem Design” by Steve Senturia published by Kluwer ISBN # 0-7923-7246-8. **Web site for the 569 chosen text**

<http://web.mit.edu/microsystem-design/www/>

### Textbook



- Microsystem Design
  - Steve Senturia (MIT)
  - First published in 2001
  - Kluwer Academic Publishers
  - ISBN 0-7923-7246-8
- Emphasis on
  - Physics
  - Modeling
  - CAD
  - Detailed case studies

Collins Weekly Lecture notes will be on the 569 Website (see versions on 569 website-download them and read carefully BEFORE CLASS. It is the student’s duty to “slow down” the lectures by asking many questions—the web has over 1200 pages of my weekly notes on MEMS TOPICS for your perusal. Most are outside the book in topics and in detail.

The supplemental reference texts for this course are:

1. “The MEMS Handbook ” Edited by Mohamed Gad-el-Hak CRC Press ISBN 0-8493-0077-0 (2002).  
When I refer in class schedule or lecture supplemental reading to Text 1 Chapter 5, I mean “the MEMS Handbook” Ch 5 etc.
2. “Fundamentals of Micro Fabrication” by Marc Madou CRC Press ISBN 0-8493-There ARE hundreds of Internet sites and some illustrative websites are given below. I list BOTH background and Application TOPICS for you to study and employ in your two semester projects.

**Some Selected WEB RESOURCES BEYOND TEXT AND MY 569 NOTES**

## **GREAT WEBSITE FOR ALL 569 STUDENTS:**

[www.memsnet.org](http://www.memsnet.org) has sections on the following:

Beginners Guide, what is MEMS, IC Process Steps in MEMS, Jobs in MEMS

Magnificent University Websites for your Case study presentations, weekly Pop Quizzes and MEMS topic papers:

“Turn off You Tube and Netflix and Let the MEMS video binging begin”

Here you can drill down to find a topic for talk # 2. More in depth talks on MEMS diagnostics and treatment employing Body Area Networks are also possible, such as the artificial pancreas

<http://arri.uta.edu/acs/jmireles/MEMSclass/MAINpage.htm>

<http://ocw.mit.edu/OcwWeb/Electrical-Engineering-and-Computer-Science/6-152JFall2003/LectureNotes/>

[http://www.enme.ucalgary.ca/~spiewaks/ENMF\\_529\\_UNIX/15\\_syllabus/\\*07\\_syllab\\_main\\_withArief.html](http://www.enme.ucalgary.ca/~spiewaks/ENMF_529_UNIX/15_syllabus/*07_syllab_main_withArief.html)

<http://www.me.berkeley.edu/ME219.SP04/Lecture/>

[http://www.ee.ucla.edu/~wu/ee250b/course\\_outline1.htm](http://www.ee.ucla.edu/~wu/ee250b/course_outline1.htm)

[http://www.eng.utah.edu/~gale/mems\\_class.htm](http://www.eng.utah.edu/~gale/mems_class.htm)

[http://www.latech.edu/tech/engr/bme/gale\\_classes/mems.htm](http://www.latech.edu/tech/engr/bme/gale_classes/mems.htm)

<http://www.dbanks.demon.co.uk/>

[http://home.earthlink.net/~trimmerw/mems/Stroud\\_Dbase.html](http://home.earthlink.net/~trimmerw/mems/Stroud_Dbase.html)

THERE ARE OTHER MEMS sources as well, besides those above, for “the inch wide a mile deep” part of the drill down portion of the course --good MEMS info hunting is rewarded by going to company websites like Analog Devices, Invasense , or TI for the accelerometer or micro mirror product lines. Texas Instruments website gives overwhelming details on their 2 million movable mirrors on a chip. Honeywell and Motorola have websites that describe their line of MEMS pressure sensors. “Turn off U tube and Netflix and Let the MEMS video binging begin”

See six brief video overviews to introduce MEMS to the novice:

1.

[http://www.youtube.com/watch?v=ZuE4oVrtEQY&feature=player\\_embedded](http://www.youtube.com/watch?v=ZuE4oVrtEQY&feature=player_embedded)

2. [http://www.youtube.com/watch?feature=player\\_embedded&v=h0cn1PovhrQ#!](http://www.youtube.com/watch?feature=player_embedded&v=h0cn1PovhrQ#!)

3. [http://www.memx.com/movie\\_gallery.htm](http://www.memx.com/movie_gallery.htm)

<http://www.youtube.com/watch?v=IAI5rLnnCBE>

The fourth one seems spooky to all but bio-engineers, as it involves MEMS scaffolds over which human cells, for example, can grow. Be sure to see the hairless mouse with a human ear growing on its back for later attachment to a human missing an ear. Presently this has progressed to growing noses and ears on human flesh—bio MEMS engineering has factories you cannot imagine MEMS engineers to be associated with.

4. The fifth takes you on a dimension tour of the entire universe of objects known to man. <http://abcnews.go.com/Technology/page/scale-universe-cary-michael-huang-california-high-school-15573968>

5. A 3-d printer can make 3-D mechanical and electrical parts as well as attempt to make human organs

6. . We will also cover MEMS atomic force cantilever microscopes that can “see” individual atoms): See [http://www.youtube.com/watch?v=ZboxMsSz5Aw&feature=youtube\\_gdata\\_player](http://www.youtube.com/watch?v=ZboxMsSz5Aw&feature=youtube_gdata_player)

## 569 MEMS SURVEY COURSE: LECTURE NOTES

**Class website: 1200 pages of my 569 class notes are found at <http://www.engr.colostate.edu/ECE569>**

**To access the ECE 569 web notes you must use:**

**Username: Student**

**Password: Power!**

GUIDE to getting maximum value from class lectures:

Listen and take minimal notes in class – but interrupt the lecture flow often with cogent questions. Be shameless; never be like a potted plant during lectures. Use lectures to get a wider angle view of MEMS ISSUES.

Enjoy the wonder of MEMS and body area networks for the next generation of health care employing body vital sign MEMS sensors. The sensors report to your cell phone or smart watch and also to the web for diagnostics from expert systems. This can be the subject for BOTH GROUP talks # 1 and 2.

**ALL OF THIS MATERIAL IS TENTATIVE AND SUBJECT TO CHANGE. Changes occur in 569 CLASS ANNOUNCEMENTS and 569 weekly memos**

sent to all students throughout THE SEMESTER, which supersede this preliminary syllabus document.

The combination of MEMS sensors and MEMS drug dispensers can also be extended to an artificial pancreas, which is **already sold commercially** for diabetics **by Medtronic** that illustrates all the wider possibilities of “body area medical networks of sensors and actuators” and we will cover this in class but talk #2 can also revisit this after I set the stage.

## **Presentations: Learn from the BEST Steve Jobs**

When you give a presentation, you face at least two hurdles.

**First**, you need to sell yourself as a credible spokesperson on your topic. Audiences need to believe in you-and that's hard enough. **Second**, you need to sell your ideas so that people come away inspired, persuaded and enlightened. Steve Jobs did both-with incredible skill. Widely considered one of the most gifted presenters ever, Jobs understood how to deliver memorable speeches in a seemingly effortless, engaging manner. His conversational tone, simple yet compelling word choice and masterful use of slides and other props helped reinforce his message in winning ways.

**When all groups investigate the same topic, you get “schooled” on presentation skills and the topic itself at the same time by your fellow students. That is, you can compare your efforts to others in your class, and learn from BOTH positive and negative example as well from the instructor. So I require talk# 1 to be on the same topic, unless your group receives special permission in advance. Talk # 2 is a MEMS topic chosen by each group and each individual based on their interest. It’s OK to redo a MEMS topic I covered in class for talk # 2, but you need to go into greater detail. You'll learn in both talks how to develop key skills, including how to:**

- **Integrate Aristotle's "Big Three"-logos/ethos/pathos-to win over audiences.** Learn how to blend logic, credibility and emotion to enliven your remarks.

- **Convey big ideas or central themes via multiple channels.** From audience giveaways to props to slides, apply the Steve Jobs approach and align all available tools to drive home key points so that people cannot help but remember them-and buy into them.
  - **Think in threes.** To explain complex processes (from chemical reactions to financial formulas), learn to cluster your main points in threes. Your audiences will thank you.
  - **Use bluntness and directness.** Rather than drop hints or dance around controversial positions just follow Steve Jobs' example and state your case boldly and succinctly.
  - **Embrace simple language.** If you need to explain complex ideas, you must speak in complex terms. Right? Well, Steve Jobs was a master at communicating complicated concepts in unmistakably clear words. Develop tools to translate your speech into plain English that's compelling and hard for anyone-of any background or educational level-to ignore.
2. **Start staff meetings with an edge.** Steve Jobs did not begin staff meetings with touchy-feely happy talk. Instead, he often provoked people or expressed disappointment in some aspect of the team's performance. But by the end of the meeting, everyone left in a positive frame of mind-

Presentation skills too can be honed through repetition, listening to talks and critique of our own talks.

## GRADING FOR 569

**A-F with plus minus 569 GRADING SUMMARY**

**A-F GRADING SUMMARY with plus minus fine tuning for 569**

<u>Total Score (X)</u>	<u>Letter Grade</u>
X > 100	A+
X > 96	A
X > 93	A-
X > 91	B+
X > 86	B
X > 83	B-
X > 81	C+
X > 76	C
X < 59	F

**Disclaimer Notices:**

**Up to date in class announcements always supersede this preliminary guide.**

**Even if you do not become a MEMS designer, 569 materials will be valuable background when specifying a MEMS sensor part in your engineering job, such as an accelerometer, gyroscope, lab on a chip or pressure sensor in a system design your company is working on. Cost** ‘the four letter word’ plays a key role in the course. Cost is just an economic measure for the common good. We will always find more function for less cost by employing IC MEMS sensor chips that include on board: signal processing, auto calibration, and wireless I/O, all on one systems MEMS IC chip. This brings up the four letter word “cost”. That is, these IC chip based MEMS systems cost only 1/100 of their large scale counterparts, yet have equal or improved performance. This is due mostly to IC economies of scale. As a consequence MEMS is growing at over 35 % per year. **With smart cell phones, replacing PC consumption, MEMS device integration will see major growth in the cell phone/watch environment .**

The materials in this introductory MEMS survey class change and each year 1/2 of material is new. Hence I judge you should acknowledge the hidden sign “**569 course under construction- pardon our appearance**”.

# MEMS TOPICS and TALKS

## OVERVIEW OF MEMS Topics in the 569 Survey Course:

In the first 8 weeks' special emphasis is on Bio-MEMS applications from oxygen sensors, glucose and blood pressure monitors to 3-d ink jet printing of organ cells and finally microfluidic bio chips that allow artificial pancreas MEMS devices as well as individual human DNA analysis for under \$1000. Matching DNA of you and your disease allows personalized medicine and appropriate treatment, especially drug choices that work for you. MEMS play the leading role to make this DNA diagnosis and matching cost effective.

Independent learning is emphasized via **TWO GROUP TALKS** and associated papers (60% of final grade). Your two group talks/papers are at the beginning and the end of the course respectively:

In depth **RECAP OF TWO GROUP TALKS FOR 60%** of grade

**STUDENTS 562 Critique Talk # 1** : . **CLASS TALK #1 DATES from 18 to 27 Feb for two weeks.**

The format is to have a critique PPT talk first, where I point out short comings, and then week later send the final PPT and word to me directly by email attachment. Do not send to CANVAS or to the grader.: [gcollins@engr.colostate.edu](mailto:gcollins@engr.colostate.edu)

At minimum four groups talk each for a full class period. As we often have >30 students in 569 this may involve groups of over 6 students per group. Suggested topics might include: **Employing Body Area Networks (BAN) for sports, medical or enhanced awareness. Apples new watch .The later can also be extended to Talk # 2** If in a second talk your group goes into depth consider the example of glucose diagnostics and control by insulin or "glucan" injection. Both are delivered from MEMS micro-pumps and microneedles. The artificial pancreas is being commercialized by Medtronic Corp.

Get your corrected PPT slides from TALK # 1 are due one week after your groups in class talk. I set the stage with an overview of microfluidics diagnostics as it impacts medical BAN. For Talk # 1 Good commercial websites are:

1. Seventh Sense Biosystems
2. Spot on Sciences
3. HemoLink

When all groups investigate the same topic, you get "schooled" on presentation skills and the topic itself at the same time by your fellow students. That is you can compare your efforts to others in your class, and

learn from BOTH positive and negative example as well from the instructor. So I require talk# 1 to be on the same topic, unless your group receives special permission in advance. Talk # 2 is a MEMS topic chosen by each group based on their interest. It's OK to redo a MEMS topic I covered in class for talk # 2, but you need to go into greater detail.

**STUDENTS 562 Critique Talk # 2** (14-23 April) for two weeks

**Groups talk** on any MEMS topic of interest to the student group, including redoing prior lectures I gave on a topic of keen interest or material covered in our text. **For example**, an artificial pancreas which is already sold for diabetics, by Medtronic that illustrates all the wider possibilities of “body area medical networks of both sensors for data and actuators for control actions”.

The format is to have a critique PPT talk first, where I point out short comings, and then week later send the final PPT and word to me directly by email attachment. Do not send to CANVAS or to the grader.

Talks are to be in PPT form and papers in WORD format. Your group and you get to drill down too on subjects of current interest, using the text, my webnotes; internet searches company websites, and your own hard research of the literature work.

All that said, the **emphasis of the 569 MEMS SURVEY course is learning not grades**. Again, even if you do not become a MEMS designer, this course will be valuable background when specifying MEMS sensors/actuators as part in your engineering job, such as an accelerometer, gyroscope, and laboratory on a chip or pressure sensor in a system design.

In a broad SURVEY COURSE such as this, group student presentations and papers are most important for both DEEP learning and for grades. As for “senioritis” your final grade will be determined mid- April and the last two weeks of the semester we will cover advanced bio-MEMS for DNA diagnostics on a MEMS chip and treatment using MEMS chips. I give MORE Details on TWO CLASS GROUP PPT BASED PRESENTATIONS AND ASSOCIATED WORD PAPERS: worth 50% of the final grade



# WEEKLY TENTATIVE SCHEDULE

You can download from the EE 569 website the Power Point web notes for each lecture. PLEASE READ THESE MATERIALS AHEAD OF CLASS.

ALL OF THIS MATERIAL IS TENTATIVE AND SUBJECT TO CHANGE.

Changes occur in 569 CLASS ANNOUNCEMENTS and 569 weekly memos sent to all students throughout THE SEMESTER, which supersede this syllabus document.

PLEASE ask questions in class to slow down the speed of lectures—I do not want you to feel you are trying to drink from a firehouse. An additional set of very current group of supplementary slides will also be available on the web in scanned format for each lecture for your convenience. Again, see CSU Web for the foils and Notes for each EE 569 lecture BEFORE each lecture as I move fast in class, but want students to slow me down to optimum speed for learning. IF I LECTURE TOO FAST PLEASE raise your hand and SLOW ME DOWN in class by asking questions and asking me to clarify your issues of interest.

## 569 Lecture Schedule, HW Due dates and Presentation/paper Due Dates

OUTLINE of Detailed Weekly Topics

### Week ONE 21/23 Jan lectures

Read Senturia chapters 1, 17 and 2.

HW # 1 assigned: Senturia Chapter 1: Problems 1 and 2, Chapter 2: Problems 1-3

Chapter 6: Problem 3 ([web search](#)) and Chapter 8: Problem 6 ([web search](#))

Assigned Take home exam # 1 on mathematical description of both R-L-C and M-B-K systems.

Assigned Pop Quiz #1

### Week TWO 28/30 Jan lectures

HW # 1 is due **Tues. 29 Jan** and Pop Quiz # 1 is due **Thur. 31 Jan**

Brief Introductions given to Various BIO MEMS Topics. See my web notes for details.

Read Senturia Chapters 3,4.

HW # 2 assigned (Chapter 17: Problems 1 and 2 (# 1 UG only 1-graduate students both) ---- Chapter 17 problems are a web search only. REMEMBER:

GROUP talk #1 is given **19- 28 Feb** —get moving early

### Week Three 4 / 6 Feb lectures

Assigned Pop Quiz #2

HW # 2 due **Tues. 4 Feb**. Pop Quiz # 2 is also due **Thur. 6 Feb**

**Looking ahead** HW # 3 is due **12 Feb** next week on Senturia Chapter 4: Problems 1-3 and 5-6 (this is the longest HW set)  
—UG's do only odd problems —graduate students do all Read Senturia Chapters 5 and 6.

**REMEMBER: talk #1 is given 18- 27 Feb. Prepare NOW not at last minute**

**Week Four 11 / 13 Feb**

HW # 3 is due **Tues. 11 Feb.** Pop Quiz # 3 due **Thur. Feb 13**  
Read Senturia Ch 7 and 8 and see HW #4 below and get started ASAP as this will be due week 6 Thursday.

HW #4: Chapter 5 Senturia: Problems 2 ,3, 5 (UG # 2 only- graduate students do all

**talk #1 for critique is given 18- 27 Feb. Student Groups TALK #1**

“Micro Fluidics in Medical Applications” or “Body Area Networks for Sports and Medical Monitoring” are two acceptable topics but NO OTHERS for talk #1 .  
Pop Quiz assigned in week # 4 and HW # 4 are due DURING Talk # 1 as follows.  
**21 Feb Thur.** HW # 4 due during talk # 1

**27 Feb Thur.** Pop Quiz # 4 due during talk # 1

Get your corrected PPT slides and WORD from TALK # 1 in to me one week after your groups in class talk. By email attachment to date when sent.

Read Senturia Chapters 8, 9 and 10. ALL students should have finished reading chapters 1-10 of Senturia at this point.

NOTE that if you have done the first 5HW sets and Pop Quizzes you are DONE  
**We ALL return to Collins MEMS lectures, after Group Talk #1 is completed.**

**Week # SEVEN 3 March / 5 March**

HOME WORK #5 assigned:

Chapter 7 Senturia: Problems 2, 7 and 8 (UG # 2 only- graduate students do all  
Chapter # 8 Senturia: Problems 2 and 3(UG do only # 2- graduate students do both

AFTER THIS HW ASSIGNMENT is completed THERE IS NO ADDITION HW required for 569—this is the last HW for 569 as the 5/10 limit is reached.

HW # 5 is assigned **3 March Tues.** and is due **Tues. 10 March**

**Week # Eight** On **10 March Tues** we only have class **NO CLASS THUR 12 March before spring break partially due to class overruns every week during critique class presentations.**

**Spring break 14-21 March** Enjoy the break you deserve a rest!!! Still Pop Quiz # 5 is due **Thur. 12 March** by midnight to CANVAS, just before spring break. HW # 5 Due **Tues. 10 March** also before Spring break.

### **Return to Collins MEMS lectures after spring break.**

**Week # Ten Tues. 24/ Thur. 26 March**

CAREFUL as only 5/10 pop quizzes and HW are required in 569: After all we have no more **required** HW assignments or Pop Quizzes after # 5 so any additional HW or Pop Quizzes you choose to do can just replace earlier PQ/HW low grades.

**Week # Eleven Tues. 31 March / Thur. 2 April**

Prepare NOW for your group talk # 2 on any topic your group chooses, even doing in greater detail what I covered in class lectures.

No assignments from 2 to 21 April to give time to prepare for TALK # 2. Do not squander this time!

**Weeks 12,13 are for preparing talk # 2. USE the time.**

**STUDENTS 562 Talk # 2 for critique (14 -23 April)** for two weeks.

The format is to have a critique PPT talk first, where I point out short comings, and then week later send the final PPT and word to me directly by email attachment. Do not send to CANVAS or to the grader.

After all Talk # 2 presentations are completed we RETURN TO 569 Web COLLINS LECTURES: Role of MEMS and Microfluidics in DNA Science and MEMS DNA Applications in final weeks 14/15/16. Last four lectures are about the EMERGING overlap of nm MEMS process fabrication (NEMS) meeting nm DNA size DNA molecules. This means MEMS structures of comparable size to fundamental bio molecules. Hence MEMS allows: DNA more rapid, higher

accuracy and lower cost DNA analysis, DNA replication and even better controlled creation of RNA fragments for use in medicine.

**LAST 2 WEEKS of the 569 SEMESTER** are for those students interested in DNA analysis and microbiology from an EE perspective. That is, we EE's make artificial structures of bio-molecule size like DNA and RNA.

569 CLASSES END **Thur. MAY 7**

Repeating Disclaimer Notice:

**Up to date in class announcements always supersede this preliminary and tentative syllabus guide.**

If you have further questions about any requirements or due dates or inconsistencies with the syllabus and weekly memos---- ask me in class so everybody benefits.