“Education is learning what you didn't even know you didn’t know”

569 Spring 2015
MEMS 3 Credits
SEE http://www.calendar.colostate.edu/

The goal of this memo is to let students know in a clear, plain and intelligible manner what is expected in 569 as regards grading, due dates and the importance of the two GROUP talks. Please contact myself or the grader if the grading is not accomplished in a timely manner.

Class Time: Tuesday and Thursday 5:30 to 6:45 in Room B101 Engr.
Instructor: Prof. George Collins, Email:
gcollins@engr.colostate.edu
GRADER: swapnilbhosale1490@gmail.com

General Instructions for Assignments

Completion of all group based HW, exams, pop quizzes, and talks/papers, outlined later in this syllabus, must be delivered by the deadline indicated by email attachment sending either to me or to the graders email by the group leader designated. See below for specifics.

Send to instructor as email attachments: only Corrected PPT slides from both talks # 1 and #2 and ALL extra credit work.
gcollins@engr.colostate.edu

SEND TO GRADER AS EMAIL ATTACHMENTS grader only, but not to me, all HW, pop quizzes and the word papers from group talks.
swapnilbhosale1490@gmail.com

Always ask the grader for an update on your grades in 569 to date: swapnilbhosale1490@gmail.com
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:

1. 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.

2. 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.

Class website: my 569 lecture notes will be posted each week and found at http://www.engr.colostate.edu/ECE569

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.

Guide through the 569 grade minefield:

1. (10 % of grade) Five HW assignments verify you have both read and studied the chosen text book for MEMS

2. (10 % of grade) Exam one verifies you know the second order DEQ solutions for both R-L-C networks and M-B-K
systems and the concept of resonance and quality factor. Mechanical systems in vacuum have B=0 which is equivalent to R=0 in electrical systems.

3. (50% of grade are two group talks) Group Talks #1 (20%) and Talk #2 (30%)

Tests your ability to search the World Wide Web, on specific MEMS topics. It also gives opportunity to learn from your own and others’ PPT presentations and WORD papers. Again this is skill highly valued in industry and we all can learn.

Talk #1 is on microfluidics for medical diagnostics or on Employing Body Area Networks for sports, medical or enhanced awareness. The later can also be extended to Talk #2. For example an artificial pancreas is now sold for diabetics by Medtronic that illustrates all the wider possibilities of “body area networks” and we will cover this in class but talks can also revisit this.

Talk #2 is entirely the choice of the student group or extending Employing Body Area Networks for sports, medical or enhanced awareness.

Practice makes perfect
Kaizen is a Japanese word for ‘continual improvement’ and is common in manufacturing as pioneered by Toyota. Presentation skills too can be honed through repetition, listening to talks and critique of our own talks.
4. (30% of grade) Ten weekly pop quizzes (total number may be reduced from 10 to 8 if student performance merits it—look for weekly class announcements). Picking up on changes verifies you listened to main points only in lectures and read weekly memos. Honestly the repetition also tests and tries your patience as does spending too much time looking up commercial MEMS vendor websites and extracting product specifications and COST information. However, frankly this is a key future job skill, when looking for any MEMS component, for a bigger job involving many components beyond MEMS parts as well.

5. (UP TO 20% of final grade) Extra credit assignments (up to 10%) and class participation (up to 10%) both show your commitments to learn MEMS materials outside the class room.

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

Letter grades for ECE 465 are on an F to A scale with plus minus fine tuning on all letter grades.

- > 98 A+
- >95 A
- >90 A-
- > 87 B+
- >85 B
- >80 B-
- > 77 C+
- > 70 C-
- etc to < 49 F
GUIDE to getting maximum value from the 569 MEMS survey

class lectures:

3. Just listen and ask questions in the class. Use lectures to get a wider angle view of MEMS than our text or any text can provide.

4. Take minimal notes in class – interrupt the lecture flow often with cogent questions. Be shameless but certainly not a potted plant during lectures.

5. Enjoy the wonder and sublime joy of MEMS sensor applications for benefit to mankind, especially medical MEMS, where the phrase “the cell phone will see you now” replaces the phrase “doctor will see you now”.

Disclaimer Notice:
Up to date in class announcements always supersede this preliminary guide.

Guide to the Due dates of assignments schedule:
I do not want any possibility of poorly explained assignments, nor lack of what is expected in assignments. Herein in this syllabus and again in weekly memos I try to provide a deep (some think too repetitive) presentation of due dates. The goal is a better organization of your time for this 569 survey MEMS course. I know you have other courses too, so 569 assignments are heavily front loaded in the first seven weeks, but lightly loaded in
the final seven weeks of the semester. In that regard I may reduce pop quizzes from 10 to 8 if the first 8 are well done.

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. This is just an economic word 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, tablets and ultra-books replacing PC consumption, MEMS device integration will see major growth.

The materials in this introductory MEMS survey class change and each year 1/2 of material is new each year. But I do save all notes together on the CSU website, for your perusal. Hence I judge you should acknowledge the hidden sign “569 course under construction- pardon our appearance”.

Second Disclaimer Notice:

Up to date in class announcements always supersede this preliminary guide. If you have further questions ask me in class so everybody benefits. Also look out for inconsistencies between the syllabus and weekly memos—ask me to clarify discrepancies. In general weekly memos trump the syllabus but not always. Again this is a survey course. Relax and enjoy the view.
OVERVIEW OF MEMS Topics:

This is an elective second semester junior or senior elective class and an elective first year graduate course. It is a survey course will be run similar to an honors class with independent learning the emphasis throughout. I view MEMS learning as a wide horizontal line of breadth followed by 4-6 fertile and specific MEMS applications of great depth including commercial vendors of the same MEMS parts compared. In short the 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 a few MEMS commercial topics “an inch wide and a mile deep”.

In the first 4 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 (50 % of final grade).

Your two group talks/papers include: Talk # 1, in the beginning of the course occurs Feb 17 –Feb 26. At minimum four groups talk each for a full class period. As we often have >28 students in 569 this may be extended to two more days of student talks till 5 March .

I encourage talk # 1 on Employing Body Area Networks (BAN) for sports, medical or enhanced awareness. The later can also be extended to Talk # 2. Of course microfluidics for medical diagnostics is the other topic for talk #1 and it impacts medical BAN. The example of insulin diagnostics is a key example.
For TALK # 2 FOUR groups talk in the two weeks between 7-16 April on any topic of interest to the student group, including redoing prior lectures I gave on a topic of keen interest. 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.

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.

I will send out a weekly memo reminding you of: last week’s material, this week’s due dates and next week’s material detailing:

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.

ECE 569 WEEKLY HOMEWORK ASSIGNMENTS (10 % of the grade ONLY 5 out of 9 HW sets are required in 569. You choose which of the 5/10 sets to do, I suggest the first five as an electrical engineer but....The assignments are due weekly as announced. HW is heavy at the start of the semester (e.g. HW#1) and HW
assignments stop by week 8 of the semester to allow time for final talks and papers as well as other course demands besides 569. HW # 1 is an opportunity to search the web for materials for both talks # 1 and #2—please use it as such and get double coverage.

MEMS written materials available to 569 students

I. 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

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

Web site for the 569 chosen text
http://web.mit.edu/microsystem-design/www/

The supplemental reference texts for this course are:

   When I refer in class schedule or lecture supplemental reading to Text 1 Chapter 5, I mean “the MEMS Handbook” Ch 5 etc.
There ARE hundreds of Internet sites on MEMS: some excellent ones are:

Some illustrative websites are illustrated below. I list BOTH background and Application TOPICS for you to study and employ in your two semester projects.

WEB RESOURCES BEYOND TEXT AND MY NOTES

GREAT WEBSITE FOR ALL 569 STUDENTS: www.memsnet.org has sections on the following:

- Beginners Guide
- What is MEMS
- IC Process Steps in MEMS
- Events
- Jobs in MEMS

Magnificent Seven Useful University Websites for your Case study presentations, weekly Pop Quizzes and MEMS topic papers: “Turn off U 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/
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 continue”

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


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


[http://www.youtube.com/watch?v=IAi5rLnnCBE](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 progresses to growing noses and ears on human flesh—bio MEMS engineering has factories you cannot imagine engineers to be associated with.


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)

7. YOUR Group---add one more GREAT website for extra credit—send to George Collins only

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, for example, how a MEMS based artificial pancreas for diabetes control works. This sets you up for TALK # 1, occurring in weeks 5 and 6, which is on the topic for ALL groups “Microfluidics and lab on a chip” or Employing Body Area Networks (BAN) for sports, medical or enhanced awareness. The later can also be extended to Talk # 2. Of course microfluidics for medical diagnostics is the other topic for talk #1 and it impacts medical BAN.
Get your corrected PPT slides from TALK # 1 in to me ASAP. They are due one week after your groups in class talk.

After group talk # 1, I then drill down in depth, from week 7 till the end of the course, with MEMS commercial sensor and actuator applications including:

1. MEMS based 3-d accelerometers and 3-d gyroscopes
   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. Pressure sensors and capacitive/ resistive touch screens for cell phones and tablets as well as for blood pressure sensors.

3. Ink jet heads for printing 2D patterns on paper but more importantly 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. High Q mechanical GHz filters for cell phone I/O on cell transceivers, called FBARS. Stereo microphones/speakers with on board signal processing, all on a chip for cell phone audio.

5. 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.

6. 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 meat for group talk # 2 extending your treatment of Microfluidic Medical applications in talk #1.

7. MEMS high Q filters (e.g. FBARS) that are replacing quartz crystal filters and oscillators in electronics circuits.

New MEMS applications such as Employing Body Area Networks (BAN) for sports, medical or enhanced awareness.

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 network. 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 45% per year. With smart cell phones, tablets and ultra-books replacing PC’s.

569 Grading Breakdown: Repeating Again for Clarity at the risk of boring you

A medley of scores is involved in the final grade including WEEKLY POP quizzes; 5/10 HW assignments, class participation, extra credit assignments, take home exams as well as two class
presentations and two papers. We will emphasize group efforts with teams of students handing in weekly HW sets and take home POP quizzes. PLEASE FORM a GROUP ASAP in the first week of the semester, for group HW, group Pop QUIZZES and for group class presentations as described in detail below. Do not be shy about reforming groups if needed to better showcase your efforts or to prevent laggards from being unfairly rewarded for group work in which they are not contributing. Your own group members MUST police this. I can help, if necessary, in a confidential manner. Completion of all group based HW, exams, pop quizzes, and talks/ papers must be delivered by the deadline by email attachment sending to both me and to the graders email by the group leader designated. I repeat:

1. Take Home Exam # 1 on linear second order systems of both R-L-C and M-B-K types: 10 % of final grade

2. Weekly HW (only 5/10 HW sets is required): 10 % of final grade

3. Group Talk # 1: 20% of final grade
   On Tues. Feb 17 I set the stage. Four student groups talk from Thur. 19 Feb. –5 March 2105, if we exceed 25 students in 569) on micro fluidics such as the Artificial pancreas.

I encourage talk # 1 on Employing Body Area Networks for sports, medical or enhanced awareness. The later can also be extended to Talk # 2. Group Talk # 2: 30% of final grade on topic of interest to the student group or extend BAN from Talk # 1

4. Ten Weekly Pop quizzes: 30 %

Add 1-5 to get the standard 100 % of the grade

More ways to get points in 569

If you participate in class (you can earn up to 10 points on the final grade) or do extra credit assignments (you can earn up to 10 points on the final grade), hence the total points available are 120 % to encourage MEMS learning and awareness. This course
is about knowledge not grades. Below are further details of the 5 pieces of the basic grade, without the extra effort points.

MORE DETAILS ON GRADING for those detail oriented

1. EXAM # 1 (10 \% of final grade)
We start the course with a take home exam that reviews dynamic response of linear second order systems, so that we understand both electrical and mechanical resonances at GHz frequencies, step responses with low and high “Q” and the mapping of R-L-C to B-K-M. Surprise, MEMS mechanical structures can resonate at GHz and with higher “Q” than electrical resonances because M can shrink and B can go to zero. Details are given in the course lectures. TAKE HOME EXAM #1 due week # 3 Tues 3 Feb: A First Group Effort to form and organize your teams.

To start the semester I give a GROUP take home Exam # 1 based on comparing m-b-k differential equations to L-R-C differential equations, due the third week of class. This shows the commonality of the mathematical descriptions, from a strictly mathematical view, the mechanical and electrical systems of LINEAR differential equations are. I am then able to illustrate to all students the common concept of “through” versus “across” variables in electro mechanical systems such as accelerometers and gyroscopes as well as atomic force cantilevers. Thereby we build model of electromechanically systems, such as “FBAR” film bulk acoustic resonators or mechanical filters , employed in cell phone transceivers,with center frequencies at GHz and “Q’s” >10^5. Avago in FTC is a world leader in FBAR sales.

Group Take Home Exam # 1 due week # 3 Tues 3 Feb

2. Weekly HW assignments 10\% of the grade as outlined below (only 5/10 HW sets is required) will comprise. Again this is entirely a group effort. Do only 5/10 assignments—do NOT DO MORE THAN 5 assignments. ALL Homework Sets are outlined in
detail in the last pages of this handout. You need complete only five of ten 569 HW assignments each worth 2 points for a total of 10 points on your final grade.

EE’s and ME’s may well choose different HW assignments. By week 10 ALL HW assignments will be finished. This also allows extra time for industrial students and others who have other obligations some weeks. A list of problems from the text is at the end of this handout. REMEMBER IS A GROUP EFFORT. I suggest you do the first 4 HW assignments, later do one that interests you, so that you are then free to work on the pop quizzes, papers and group presentations later in the semester.

In HW # 1 and # 2 you all will as a GROUP search the web and find RELEVANT MEMS websites from: Universities, companies, National Laboratories and REVIEW papers published in REVIEWED engineering and Science journals as well as in the professional magazines written for the general audience describing MEMS devices and applications.

Try your best to overlap this web search task with your TWO MEMS presentation/paper goals for weeks 5- 6 and weeks 12-13. Get a head start on your group talk # 1 on Microfluidics and talk # 2 entirely of the group’s choice by doing MORE than required and handing it in as extra credit. Focus early on micro fluidics background research for talk # 1 and later topics of interest to your group for talk # 2.

3. Group Talk #1/Paper #1 for 20% of final grade (WEEKS 5 and 6)
On Tues. Feb 17 I set the stage as I talk first on an overview of microfluidics diagnostics or on Employing Body Area Networks (BAN) for sports, medical or enhanced awareness. The later can also be extended to Talk # 2. Of course microfluidics for medical diagnostics is the other topic for talk #1 and it impacts medical BAN in Talk #2.
Four student groups talk from **Thur. 19 Feb. –5 March 2105**, if we exceed 25 students in 569) on micro fluidics as applied to medicine or on Body Area Networks and will count for 20%, both individual and group efforts will be counted in the talk # 1 grade. 15 % on the in class talk using PPT slides and 5% for paper in Word, so identify your individual contributions. USE materials in chapter 10 fluids. Oral talk #1 will be for 45 minutes (roughly 40-55 power point slides) and will have a companion paper written in word (double spaced) of length ~25 pages including references in IEEE format. PPT talks are such that only your slides do not stink, just other peoples do. Remember PPT talks are like Karaoke—everybody claps after the talk, but often it was not that good. I hope you learn how to do better by doing it or seeing it done by others. Talk # 1 is a fixed topic for ALL groups for this reason, so ALL students will talk about the same general topic to see how their talk compares to others, to learn BETTER presentation skills by both again both listening and looking at others PPT slides as well as preparing their own.

I will give a broad overview of microfluidics as well as BAN. In your group talk in microfluids, then drill down on one or two specific medical microfluidic applications. An example would be the artificial pancreas and the body area network that supports its operation. Glucose test patches or GOOGLE eyewear that’s samples glucose in tears and associated microfluidic insulin injection MEMS pumps employed in diabetes treatment are in open season. I will go over both in class. Gases, like breath are fluids too. Breath analyzers for asthma or alcohol levels and commercial companies working in that area and their product specifications are all fair game. In addition, Get your corrected PPT slides from TALK # 1 in to me ASAP. They are due one week after your groups in class talk. Again I allow talk # 1 and 32 to be on **Employing Body Area Networks (BAN) for sports, medical or enhanced awareness.** The later can also be extended to Talk # 2. Of course
microfluidics for medical diagnostics is the other topic for talk #1 and it impacts medical BAN.

Group Talk #2/Paper #2 30% total on the final grade: Four student groups talk (Tues. 7 April – Thur. 16 April). This will count for 30% total on the final grade, 25% on the in class talk using PPT slides and 5% for paper in Word. Talk # 1 Employing Body Area Networks (BAN) for sports, medical or enhanced awareness can also be extended to Talk # 2.

Your group picks a MEMS topic of interest to all of you. The first ten weeks of lectures will expose you to the variety of possible talk # 2 topics in MEMS, via an overview survey of present MEMS applications during the first eight lectures. This is the “mile wide an inch deep” part of the course or the horizontal section of the course “T” of knowledge structure. —be sure to attend these early lectures and pay attention if something ignites your interest and choose it for your group’s talk #2 as early as week 4.

Explore MEMS applications in your area of interest in a new web resource, the MEMS Showcase.

You will find industry examples of MEMS simulations from diverse application areas such as sensors and actuators, ultrasonic transducers, RF, and BioMEMS.

Check out the resource now: http://comsol.com/c/12yx

Both individual and group effort will be scored in the talk # 2 grades, so identify your contributions. Oral talk #2 will be for 45 minutes (roughly 40- 55 power point slides) and will have a companion paper written in word (double spaced) of length ~25 pages including references in IEEE format.

Please first give a broad overview of your chosen topic, then drill down on one or two specific sub- topics only in detail and give
commercial companies working in that area and their product specifications.

Get your corrected PPT slides from TALK # 2 in to me ASAP. They are due one week after your groups in class talk.

5. I count 30% for weekly class pop quizzes, which are ALL of take home variety. Ten pop quizzes are envisioned to be assigned but I may reduce this number. This is a drill deep exercise using my notes, manufacturer’s application notes from MEMS vendors and papers from the MEMS literature.

This is entirely a group effort and not an individual effort. I make every attempt to use early pop quizzes to have you research the topic “microfluidics” or Body Area Networks for Talk # 1 so you are better prepared.

A-F GRADING SUMMARY with plus minus fine tuning for 569
Letter grades for ECE 569 are on an F to A scale with plus minus fine tuning on all letter grades.
> 98 A+
>95 A
>90 A-
> 87 B+
>85 B
>80B-
> 77 C+
> 70 C-
Etc. to < 49 F

All that said, the emphasis of the 569 MEMS SURVEY course is learning not grades.
There will be no final exam. Again, even if you do not become a MEMS designer, this course will be valuable background when specifying a MEMS sensor part in your engineering job, such as
an accelerometer, gyroscope, and laboratory on a chip or pressure sensor in a system design.

OVERVIEW OF For the first 8 MEMS Lectures “the mile wide and an inch deep” lectures or “Let the MEMS lecture bingeing begin”:

We will cover a wide spectrum of MEMS applications with information “a mile wide and an inch deep”. This gives a broad background of commercial MEMS devices which ALREADY sell billions of devices per year. It also allows the class to pick and choose applications they wish to see developed in detail. 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. I also do not you acting like a potted plant—so be active and ask questions—“you are paying and I am being paid”

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 by week 13 of the semester 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. Medical sensors and MEMS based treatment a very new and fast growing application of MEMS. So this portion has lots of opportunity for extra credit.

More Details on TWO CLASS GROUP PPT BASED PRESENTATIONS AND ASSOCIATED WORD PAPERS: worth 50% of the final grade

As TWO in class group talks and papers play such a big role in learning and grades I cover this next in more detail below and provide guidance. The two group talks I assign and associated group papers are distinct with different requirements and different due dates.

The course therefore emphasizes practice in both ORAL presentations in PPT and report writing in WORD using IEEE
standard referencing of all sources. Penn State’s Michael Alley has an excellent talk on PPT presentations located both on YouTube and on www.the-scientist.com. Your technical presentations will be GROUP efforts to simulate your next environment—industry or graduate school. This group effort is purposeful to get students familiar with the team efforts that they will SOON encounter in industry. For group efforts Microsoft has versions of Word and Power Point that reside on servers at Microsoft—@ office live.com—moreover this allows MULTIPLE users to log on and work on the SAME document together.

GROUP TALK # 1 and Paper # 1: The topic is “ Micro Fluidics for Medical Applications or alternatively Employing Body Area Networks for sports, medical or enhanced awareness. The later can also be extended to Talk # 2. I talk on Tues. Feb 17 to present the basics. Then three groups talk from Thur. 19 Feb to Thur. Feb. 26 and probably beyond to Thur. 5 March

Talk # 1 is given in weeks 5-6 of the semester. USE materials in chapter 10 fluids. MEMS Microfluidics and medical applications to LOWER COST and FASTER medical diagnostics is the single allowed topic so ALL students will talk about the same general topic of combining diagnostics and treatment injections employing a sense command and control body area network. Each group will focus different aspects even with a focused topic like this.

MEMS in Micro Fluidics—Lab on a chip for chemical, DNA or medical fluids and gases (breath) diagnostics, Micro fluidics is used for both sample preparation, movement of reagents and bioassay. Liquid chromatography (LC) coupled with mass spectroscopy (LC_MS) is more sensitive and discriminates better between species. LC-MS (mass spectroscopy) is a big business and the front end LC is done on a microfluidic chip which Agilent sells commercially. See the company websites for the following companies: Affymetrix, Nanogen, Fluidigm, and Agilent ALL emphasize microfluids and optical detection. In contrast, direct electrical detection of DNA is possible using the technologies
developed by for example Illumina and Pacific Biosenses etc. The company named “Organovo” aims to print 3-D organs with even human blood vessels with ink jet printers from LIVE cells that act as ink. The cells can live 40 days for drug tests. They also aim long term to print whole organs.

The National Institute of Health Human Genome website also has a GREAT introduction to DNA and DNA analysis—http://www.genome.gov/10506367. Oral talk will be for 45 minutes (roughly 40-55 power point slides) and will have a companion paper written in word (double spaced) of length ~25 pages including references in IEEE format.

Skills in giving PPT presentations and writing WORD papers are honed and learned in TALK #1. This allows for talk and writing skills improvement via feedback from the instructor and fellow students as well as watching others good and bad presentations on the same topic: microfluidics.

For your talk and paper #1 you will need to submit to me an email attachment of your PPT slides and to the grader your groups Word paper by email, one week after the talk. Talk # 1 allows groups to avoid future end of semester disasters in TALK # 2 and paper #2!

Key Items TO INCLUDE IN TALK #1: Microfluidics MEMS Chips for an artificial pancreas or I encourage talk # 1 on Employing Body Area Networks for sports, medical or enhanced awareness. The later can also be extended to Talk # 2. Medtronics diabetic management system is an excellent illustration of the future.

I will cover theory of flows in micro channels driven by pressure or electric fields, MEMS materials employed in the microfluidic chip manufacturer, low cost fabrication techniques of the chips etc. Your group talk # 1 should focus on; commercial microfluidic chip sets available that work in tandem with body area networks such as the artificial pancreas.
You are free to speculate on Lab on a chip analysis of body fluids for medical diagnostics and DNA determination or protein analysis from micro size bio samples. GOOGLES new “moonshot project” is baselining the human body. Use the web to research the topic. Two simple microfluidics chip company websites of note are from: Fluidigm and Fluigen. In addition, you can search websites of Agilent’s bio division, Illumina, Pacific Biosciences, Curagen, and Affymetrix ‘s DNA array based Lab on a chip website is also illustrative

MEMS TALK #2

Between Tues.7 April- Thur. 16 April FOUR GROUPS. Each group freely picks a MEMS topic of interest to them. It could be a repeat in more depth of TALK # 1 I encourage talk # 1 on Employing Body Area Networks for sports, medical or enhanced awareness.

My lectures will expose you to the variety of possible talk # 2 topics in MEMS, via an overview survey of present MEMS applications during the first eight lectures. This is the “mile wide an inch deep” part of the course or the horizontal section of the course “T” of knowledge structure. —be sure to attend these early lectures and pay attention if something ignites your interest and choose it for your group’s talk #2 as early as week 4. Talks and associated papers after week 13 of the semester are by special permission only.

The second MEMS talk/paper # 2 will be a completely student chosen on a Case Study MEMS Application of interest to the student group or Employing Body Area Networks (BAN) for sports, medical or enhanced awareness. Microfluidics for medical diagnostics could be one focus for talk #1 and it how impacts medical BAN such as an artificial pancreas. The only requirement for Talk # 2 is that it has MEMS COMMERCIAL products involved or is just interesting MEMS science project research from industry of government labs. The artificial eye is a good example, where in class we discussed
Stanford University research in Palanker’s lab and “Second Sight a commercial artificial eye vendor.

Do something that excites your interests. For example, Coventor a vendor of CAD analysis tools for MEMS. Coventor’s new MEMS tool MEMS+ makes behavioral and electrical models as well as a subflow for creating MEMS elements and integrates them into Cadences Virtuoso. It’s entirely the group’s choice for the second group talk in the MEMS course, assuming it is of course MEMS related.

Alternatively for your group’s TALK # 2, as we covered so many MEMS topics—go back and redo 1-2 MEMS topics I covered but do it better and in greater detail for Talk # 2 using resources I did not employ.

This talk # 2 MEMS topic of group choice should be decided by at the LATEST by week 8 of the semester and given in weeks 12-13 of the semester. Check your ideas for talk #2 with me early in week 4 to avoid problems. The group’s progress on their talks and papers should occur throughout the semester step by step not all at the last minute. Oral talk will be for 45 minutes (roughly 40- 55 power point slides) and will have a companion paper written in word (double spaced) of length ~25 pages including references in IEEE format for the comparative case study as was the case in talk/paper #1. Provide both paper copies and a CD, which contains all your efforts on both the PPT talk and the Word paper.

Finally as a last stand backup for talk # 2 for those 569 students without their own burning interest in commercial MEMS products or current BIOMEMS research they may choose one chapter only from our text Chapter 23 (gas sensors such as air flow meters for automobile ignition control) BUT you must also search for commercial MEMS gas flow sensors. This is a fallback paper choice if you have trouble picking a MEMS topic on your own and need our text to guide you. After the Japan earthquake there was
a shortage of these MEMS air flow chip meters that stopped auto
assembly lines worldwide.

II. 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 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

COMPLETE ONLY 5/10 HW assignments but all 10 pop quizzes.

OUTLINE of Detailed Weekly Topics

Week ONE  20/22 Jan
Assign Take home Exam # 1 and brief Introductions to
various MEMS Topics. Read Senturia chapters 1, 17 and 2
Assigned 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)
Take home exam #1 on mathematical description of both R-L-C and M-B-K systems will be due Tues. week #2
Assign Pop Quiz #1 due Thur. week #2.

Week TWO  27/29 Jan
HW # 1 due Tues. 27 Jan and Pop Quiz # 1 is due Thur. 29 Jan
Brief Introductions given to Various 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.
See also extra credit problems 2-4. REMEMBER: talk #1 is given weeks 5-6—get moving early on this task.

Week Three 3/5 Feb
HW # 2 due Tues. 3 Feb. Pop Quiz # 2 as well as exam #1 is also due Thur. 5 Feb

HW # 3 Assigned:  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 weeks 5-6—get moving early on this task.

Week Four 10/12 Feb
HW # 3 is due 10 Feb. Pop Quiz # 3 due Thur. Feb 12th
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 Assigned: Chapter 5 Senturia: Problems 2 ,3, 5 and Extra credit #6  (UG # 2 only- graduate students do all

Weeks #5 & #6: Student Groups TALK #1 “Micro Fluidics in Medical Applications” ( Tues. Feb 17- Thur. 27th). Tues.17 Feb. 1
will lecture on microfluidics in general to get basic ideas out of the way.

From Thur. Feb 20- Thur. 27th, three student groups present their microfluidic papers with emphasis for example on Illumina, Pacific Bio senses, and other companies that do electrical based DNA sequencing.

Pop Quiz assigned in week # 4 and HW # 4 are due as follows.

- 20 Feb Thur.   5         HW # 4 due
- 27 Feb Thur.   6   Pop Quiz # 4 due

Get your corrected PPT slides from TALK # 1 in to me ASAP. They are due one week after your groups in class talk. 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 4 HW sets you are DONE with 4/5 HW and need choose only one more HW out of HW sets 5-9 listed below.

Return to Collins MEMS lectures, after Group Talk #1 is completed.

Week # SEVEN 3/5 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—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 10 March only we have class// 12 March no class

HW # 5 Due Tues. 10 March.

WE HAVE NO CLASS Thur. 12 March before spring break

Still Pop Quiz # 5 is due Thur. 12 March by midnight via email attachment, just before spring break.

Week # Nine is SPRING BREAK 14-22 March Enjoy the break!!!

Return to Collins MEMS lectures after spring break .

Week # Ten Tues. 24/ Thur. 26 March
HW # 6 maybe needed to reach 5 HW sets for some students, 5 sets is all that is required.
Pop Quiz #6 is due Thur. 26 March

CAREFUL: Upcoming Pop Quiz # 7 and #8 is combined by Collins into a double credit Pop Quiz due Thur. 16 April during second week of Talk # 2. After all we have no more HW assignments in 569 so you have more time to do Pop Quizzes.

Week # Eleven Tues. 31 March/ Thur. 2 April
HW # 7 is it needed to reach 5 HW sets?? If not needed, no HW is assigned.

We may review MEMS Topics presented to date this week to catch our breath in this survey course. Prepare for your group talk # 2 on any topic your group chooses ,even doing in greater detail what I covered in class lectures.

Weeks 12 and 13 are for talk # 2

Four groups will present (Tues. 7 April- Thur. 16 April)
Combined Pop Quiz # 7 and 8 are due Thur. 16 April, during talk # 2. See below.

16 April  Thur.     Combined POP Quiz # 7 and 8 is DUE last day of TALK #2

MEMS Talk # 2 CORRECTED PPT slides must be delivered to me ONLY by email one week after your group presents in class.

Word paper is sent to the grader ONLY at that same time by email attachment.

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 3 WEEKS of the 569 SEMESTER are for those students interested in microbiology from an EE perspective.

<table>
<thead>
<tr>
<th>Date</th>
<th>Week #</th>
<th>Tues due</th>
<th>Thur. due</th>
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<tbody>
<tr>
<td>21/23 April</td>
<td>14</td>
<td>DNA, RNA and cells</td>
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<tr>
<td>28 April/ 30 April</td>
<td>15</td>
<td>MEMS DNA Microarrays</td>
<td>Pop Quiz# 9</td>
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<tr>
<td>5/7 May</td>
<td>16</td>
<td>Central Dogma of MicroBiology</td>
<td>Pop Quiz # 10</td>
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CLASSES END Fri. MAY 8

Disclaimer Notice:
Up to date in class announcements always supersede this preliminary 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.

I RECAP ALL the HW ASSIGNMENTS in one place for your reference : BUT ONLY 5 are required

Again do only 5/9 HW SETS. Note the HW assignments below are DIFFERENT for graduate students (problems chosen are harder) and 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.

Homework #1  DUE WEEK #2 Tues. 27 Jan. Search PROBLEMS BELOW ARE FOR ALL STUDENTS—this problem statement is repeated on your HW handout. Senturia Chapter 1: Problems 1 and 2 Chapter 2: Problems 1-3
Senturia Chapter 6: Problem 3 (web search) and Chapter 8 : Problem 6 (web search). In addition research your talk # 1 Microfluidics topics for extra credit and show the top 10 websites you found.

HOME WORK #2:  Due Week #3 Tues.3 Feb.
Senturia Chapter 3: Problems 2-4 (UG do 2 and 3: graduate students all)
Chapter 17 : Problems 1 and 2 ( # 1 UG only 1-graduate students both) —- Chapter 17 problems are a web search only. Subsequent HW assignments may be shortened—watch for in class announcements

HOME WORK # 3:  Due Week # 4 Tues.10 Feb
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
HOME WORK #4: Due Week # 6 Thur. 19 FEB. , at the last day of group talk #1
Chapter 5 Senturia: Problems 2,3 ,5 and Extra credit #6 (UG # 2 only- graduate students do all. Chapter 6 Senturia: Problems 1 and 2 (UG do only # 2- graduate students do both AFTER TALK #1 is completed

HOME WORK #5: Assigned Tues. 3 March and Due Tues. 10 March.
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

ONLY 5 HW's are required so if you did the first 5 you are DONE with HW for 569. Optional HW sets are listed below but without due dates.
HOMEWORK # 6 if needed because your group did not do 1-5 HW sets
CHAPTER 9 problems 1, 3, 5 (UG do only # 3 - graduate students do all).

HOMEWORK # 7
Chapter 10 Senturia problems 2,4 (UG do problem 2- graduate students do all)

HOMEWORK # 8 Chapter 16 Senturia: NOISE Problems 1, 4(UG), 5

HOMEWORK # 9
Chapter 13 Senturia: Fluids Problems 3, 4 (UG), 5
USE materials in chapter 10 for group talk #1 and #2.

ECE Students are the most important people at CSU.
Not dependent on faculty.
Faculty is dependent on them.
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!