

EXCELLING AT TEACHING SCIENCE AND¹ ENGINEERING COURSES

PROF. D.T. JOHN *

* The presentation's author and his affiliated institution were assigned fictional names because their identities are irrelevant to the purpose of this presentation, which is to offer instructors ideas about improving their teaching techniques

AB University*, 2026

Why should I spend time on this presentation?

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- If your teaching is rated among the top 10% of instructors in your department, then you do not need this presentation.
- But if you're willing to explore tools that might improve your teaching effectiveness, then it's worth spending 15 minutes on this presentation.

The Challenge

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- According to a recent article in the Chronicle's 2026 Mission Issue (<https://www.chronicle.com/package/mission-issue-2026>), "in the aftermath of the Covid era, schools and colleges are facing an **unprecedented challenge**: How to educate students whose analytical skills have declined and when something is hard, they are less likely to want to work through it." And this is particularly true in science and engineering courses; **when a student does not learn calculus and other mathematical tools in lower-level college courses, he/she will struggle and fail in higher-level science and engineering courses.** Electronic recording of the lectures given by instructors-- which was originally intended to help students, particularly during the Covid era—has evolved into a poisonous drug because it offers the student a seemingly easy way to skip in-person class attendance. The consequences are: poor understanding of the course material, inclination to use ChatGPT to do homework problems, poor performance on exams, and a high likelihood of failing the course.

The Outcome: Based on interviews with engineering instructors at many US universities

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❖ Attendance:

- Many universities acknowledged that **in-person class attendance has dropped significantly (by 10-50%) in lower-level classes** (but not in senior-level or graduate courses), and **in some cases the attendance was as low as 20%**.
- In universities where recording of the lectures is available, many **faculty have decided to no longer allow the recordings**. Those faculty report that in their classes, **attendance is higher than 80%, and closer to 90%**.
- In some universities, **instructors allocate up to 20% of the final grade to attendance** (they use “iClicker polling” or QR registration). Attendance is greater than 90%.

❖ Performance:

- In classes that use recordings and apply no penalty for not attending, the fraction of students who “should” fail is greater than 40%, but because of the “pressure imposed by college and department administrations, the reported failure rate is only 10-15%.”
- **“We are struggling with a bimodal distribution. Half the class has a good distribution of A, B and C’s, but there are almost as many D’s and F’s as A’s and B’s!!.”**

Why This Presentation?

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- ❖ I enjoyed teaching, and found the experience highly rewarding.
- ❖ Over the years, I developed an approach that seems to appeal to students. Consequently:
 - The students learn a great deal more, and
 - The students and the instructor form a genuine bond.
- ❖ I'd like to share with you an overview of how I “connect” with the students, and the payoff resulting from that.
- ❖ Given the struggle that many faculty and students are currently experiencing, a presentation of this teaching approach is particularly timely!

Teaching

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- **Mechanics:** Lectures, HW, Exams, Labs, etc
- **Culture:** connection between the instructor and the students
- **Superior Teaching** = Both components are top notch!
- -----
Unfortunately, many faculty ignore the “culture” part.

A relevant true story: A faculty colleague at another university was getting depressed because he felt that “the students hated him” and was considering early retirement, after 35 years of teaching. After counseling with an academic therapist, he decided to change his teaching style by **engaging the students through discussions, projects, and in-class exercises**, . By “connecting this way with the students”, he transformed the entire relationship into a constructive educational dynamic that both he and the students found to be rewarding. Attendance in his class improved from 20% to over 90% !!

Topics in This Presentation

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1. Bragging!!
2. One Week Before 1st Day of Class
3. 1st Day of Class
4. 1-on-1 Meetings
5. Lecture Style
6. Tech Briefs
7. Grades and Exams

Let me start by bragging about my teaching!!

(The intent is not to brag, but rather to get your attention)

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- Voted by students: Eta Kappa Nu ECE Professor of the Year: 2018, 2013, 2006, ...
- 2016: All university students were invited to vote for their favorite professors. They selected the top 10 from among the university's 4000 faculty.
- Campus Life Student Newspaper:

10 Best University Professors that Keep You on Your Toes!

Prof. John was the only faculty member from among the 500 College of Engineering faculty who made the list.

Student Comments

- **Student 3:** Prof. John is absolutely the best teacher I've ever had. Not only is he talented as a scientist and instructor, he is genuinely interested in the success of his students. From the first day **he makes his expectations for students very clear,** and if you work at the standard he sets, you will be very successful and **learn an incredible amount.** Fantastic Professor.
- **Student 6:** Professor John is a great teacher! He gives clear explanations and helpful examples. I also feel that he genuinely cares about the success of all of his students which really encouraged me to put more time and effort into the class. **I also really like the technology brief** in class and the textbook. I wish other classes included more examples of relevant applications of course material.

Student Comments

- **Student 8:** Excellent lecture style. I liked the lecture slides in tandem with the notes from class. Some professors just read slides, some have no slides at all, but this course struck an excellent balance.
- **Student 9:** Prof. John is the best professor I have had in EECS through my 5th semester. He recognizes that we are enrolled in school to learn, not to earn a grade.
- **Student 16:** Somehow, his voice makes things even more interesting than they already are. My mind becomes a sponge for knowledge during class.
- **Student 25:** Professor John is very thorough and efficient in his lectures, and I appreciate how he makes a point to tie what we learn in class to real world applications.

Course Components

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- EECS 215 Intro Lecture on Day 1
- Teaching Style/Format
- One-on-One meetings
- Thursday Open Questions
- Quizzes and Exams
- Bridging the gap between Fundamentals and the Real World
- Class Demos

First Contact With Students

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- About **one week before the first class** of the semester, I send a message to the students via Canvas:
 1. **Welcoming** them to the course and promising them a rewarding learning experience.
 2. Instructing them to **download from Canvas the PPT slides for ch1, printing a hard copy, and placing it inside a 3-ring binder.** They are to bring the binder to class on Day 1.
 3. **And Instructing them to read and learn pages 1-15** in the textbook, and be prepared to take a **Quiz** to answer questions about the content.

It is important to get the students attention before the start of the course. The message sets the tone for the course and the instructor's expectations.

Day 1 (Slides 12-32)

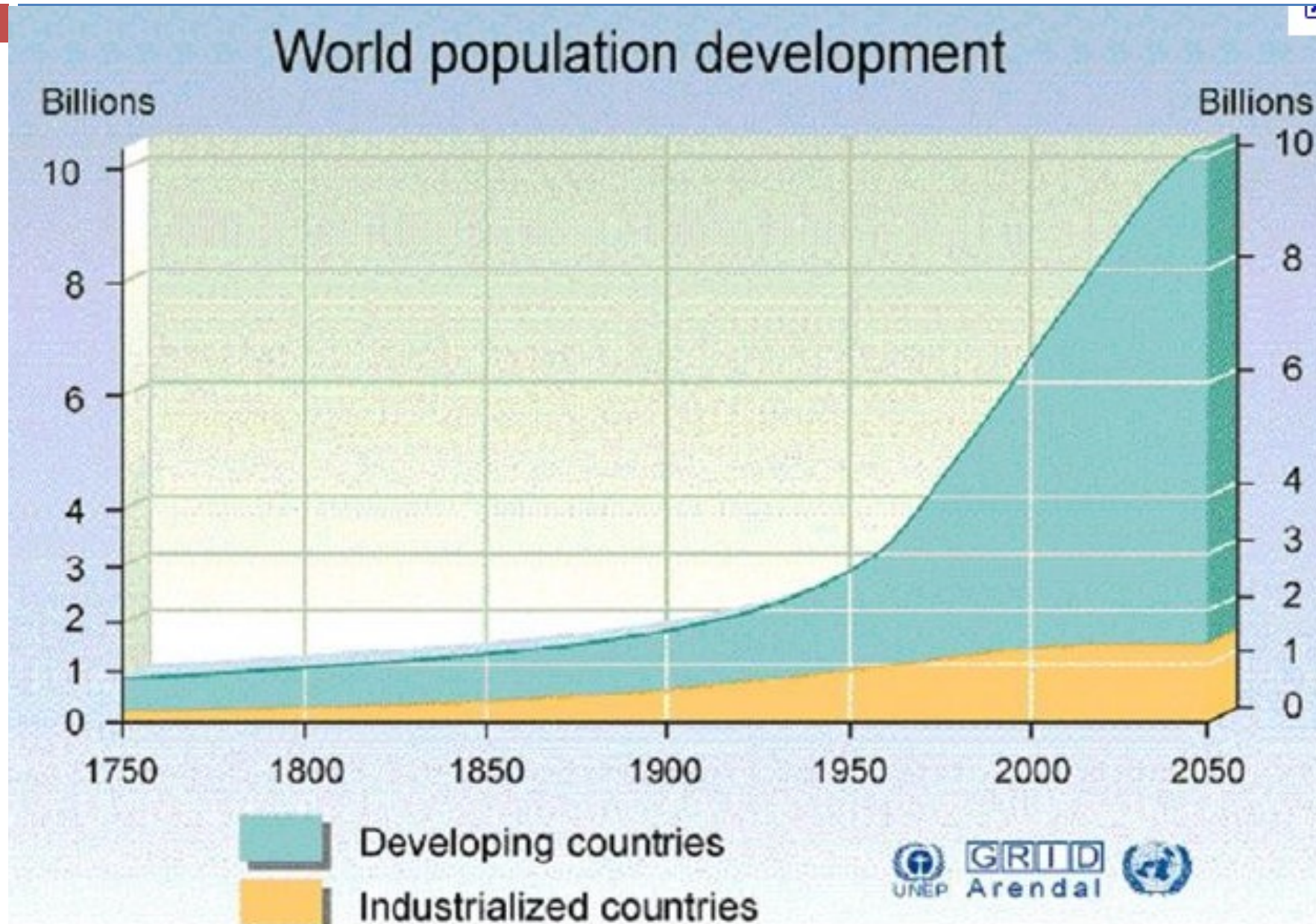
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- Intro about the course
- Quiz 1 (**gets their attention**)
- Binder test: all students are asked to raise their binders to **show that they printed a hard copy of ch1 slides and inserted them into the 3-ring binder.**
- For the few who had failed to bring a 3-ring binder containing the ch1 slides, they are told they will be **given one more chance**, and if **they do not comply** by the next class meeting, **they should stay away from the course!**

The role of the 3-ring binder is explained in slides 26-29.

Two slides to illustrate how much the world needs scientists and engineers

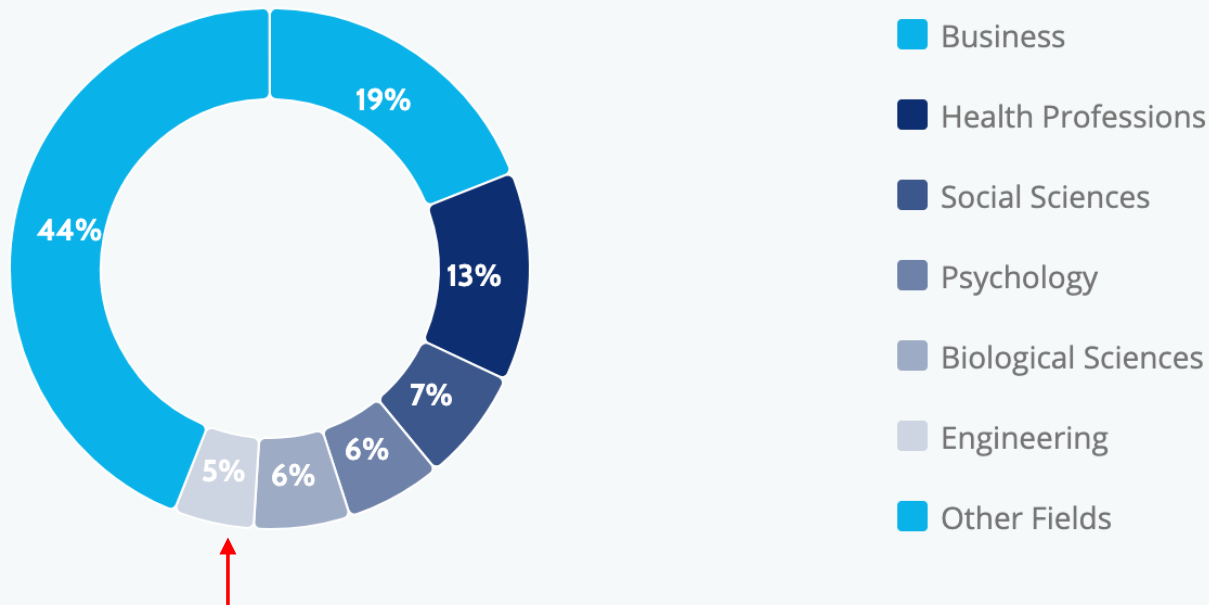
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The World Needs Scientists and Engineers

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Distribution of Bachelor's Degrees by Major Field (2021-2022 data in percentage) ☰



Source: NCES

Designed by [Research.com](https://www.research.com)

Of the 2 million BS degrees granted in the US, only 5 % are for engineering degrees

Society has invested in you in a big way! How do you intend to repay it?

Course Objectives

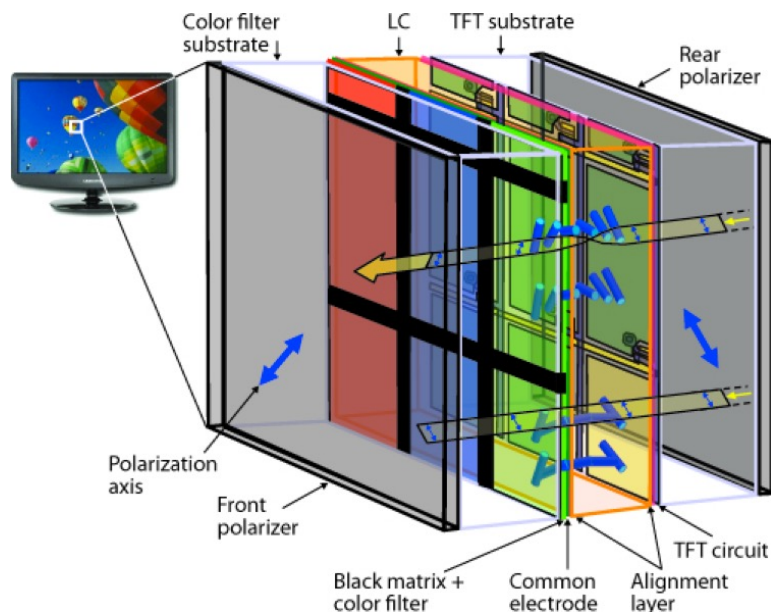
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- To equip the EE and CE major with a fundamental understanding of electronics
- To introduce the student to the engineering applications of electronic circuits
- To help the student develop the **learning skills** and **self discipline** necessary for success as a professional
- To **enjoy** the learning experience!

By the end of the course, You should know:

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□ How an LCD works



How cell-phone antennas work



Why do wireless bands operate at 2.4 and 5 GHz?

Cell-Phone Architecture

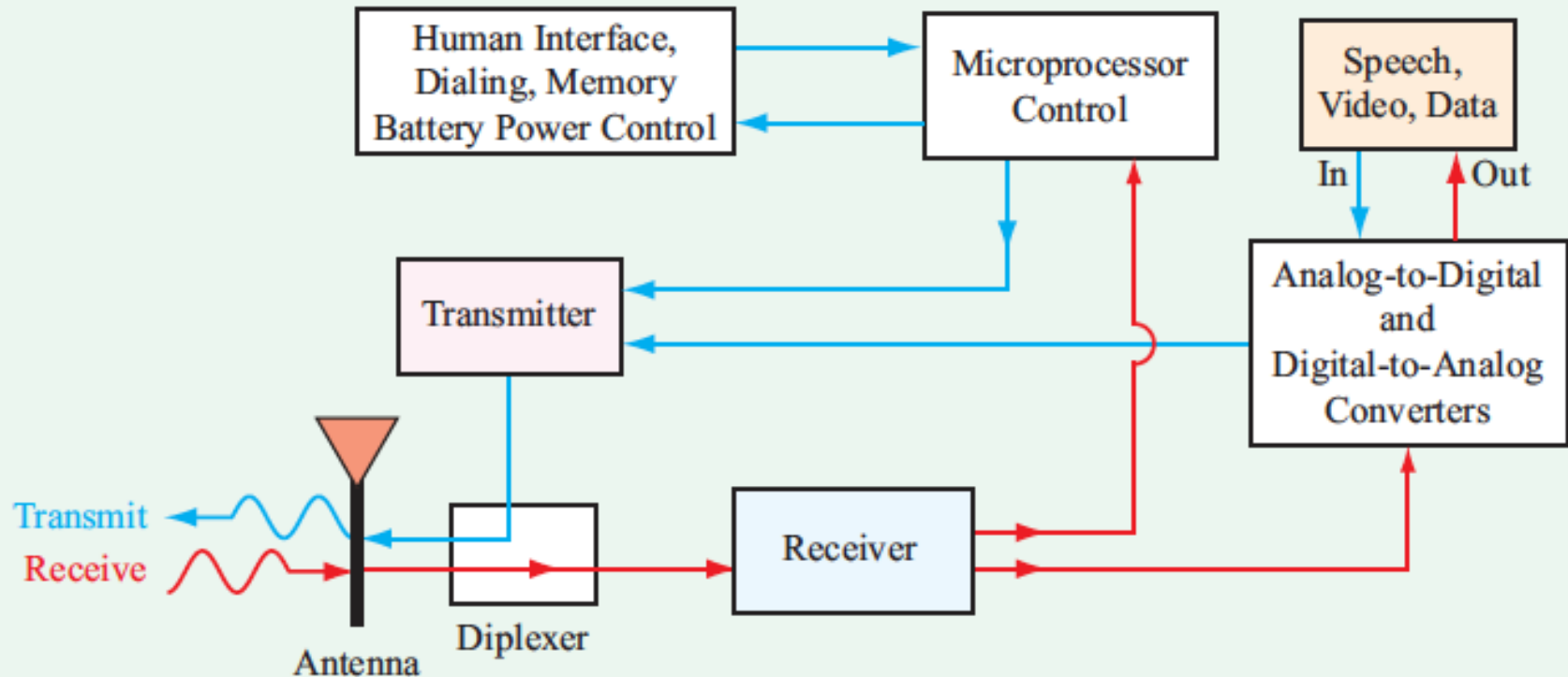


Figure 1-2: Basic cell-phone block diagram. Each block consists of multiple circuits that together provide the required functionality.

What you may expect from me

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1. **Commitment** to help you succeed
2. Good course **organization**
3. Great lab and course **GSI**s

What I expect from you

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- 1. Taking the course very **seriously**
 - A~18 hrs/wk
 - B~15 hrs/wk
 - C~12 hrs/wk
- Good **organizational skills**, always submitting assignments on time
- Acting with **honesty and integrity**
- Be **mindful** of instructors and Fellow students

Course Team

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- Course Instructor: Prof. John
- Course GSI: Tom F.
- Lab Instructors:
 - Tom F. (3 sections)
 - Kyle H. (1 section)
 - Bradley H. (1 section)
- **Textbook**

Circuit Analysis and Design

Course Technical Dimensions

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- **Lectures:** 4/wk, which may include
 1. Demonstrations
 2. Problem-solving sessions
 3. Presentations on various topics
 4. **Unannounced quizzes (one or more every week)**
- **Lab Experiments**
 1. Prelab: reading and calculating in preparation for In-Lab part
 2. In-Lab: 2-hour experiment
 3. Post-Lab Report: Analysis of results

Couse A-Z

1. **No food** or drink in class except water, **no laptops or cell-phones**
2. Class will always start and end on time. **Avoid coming in late.** If you need to leave before the class is dismissed, let me know at the beginning of the hour
3. All **homeworks** are due by 5pm on the due date.
4. For **unpicked-up homeworks**: check with course GSI (Tom F.).

Course A-Z cont.

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5. **Working Together:** You are encouraged to work with classmates on homework problems. However, you should state on each problem who you worked with.
6. **Grading:** NOT on a curve. You will compete against your own potential, not against others. (**More on grades and exams later**)
7. **When you need help:**
 - a) **Lab-related:** Your lab instructor
 - b) **Mechanics** (how to compute a complex number, integrate a function, approach solving a problem, etc): **Course GSI. Check schedule***
 - c) **Concepts & careers:** Prof. John D.T.
8. **Getting To Know You:** 5-10-minute individual meetings . Sign up at: <https://www.eecs.....> Meeting dates are on 25 September , 2 October, and 9 October.

The schedule includes 15 hours a week during which at least one of the 3 GSIs is available to answer questions related to homework problems. This arrangement frees the instructor to meet with the students to discuss concepts, careers, and related topics.

Course A-Z cont.

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9. Important Dates

Midterm 1 : October 15, 6-8pm

Midterm 2 : December 2, 6-8pm

Final Exam: December 18, 7-10pm

10. Grade Points

Exam 1 150

Exam 2 150

Lab 200

Homework 150 (lowest HW grade deleted)

Final Exam 250

Quizzes 100 (lowest quiz grade deleted)

11. No phones, tablets or computers in class

12. No camera recordings of lectures

Teaching Styles

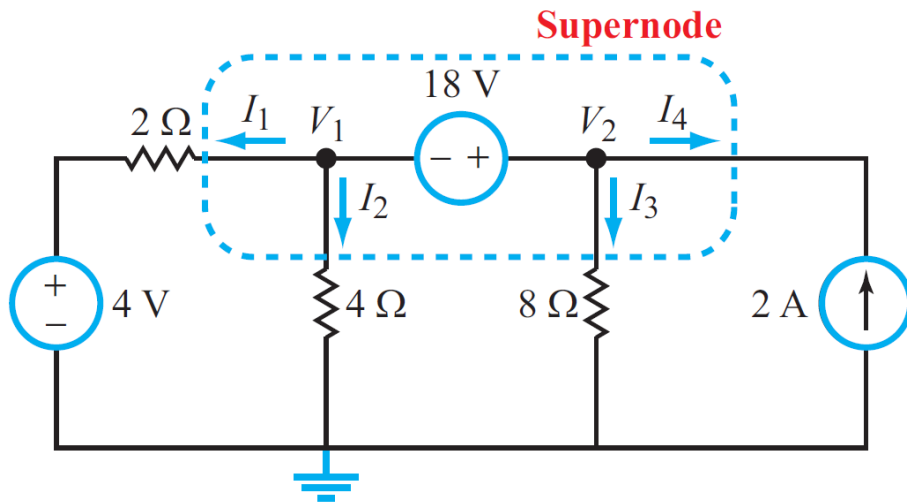
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- **All Powerpoint:** Easy for instructor, great for refresher courses, **Not** conducive to learning new material
- **All on White Board:** difficult to draw some diagrams, photos are even harder
- **Mixed Model:** Take advantage of technology, but not at the expense of learning. **This is the style we use in this course.**

Example 3-3: Supernode

(Slide is part of PPT slides downloaded by the students)

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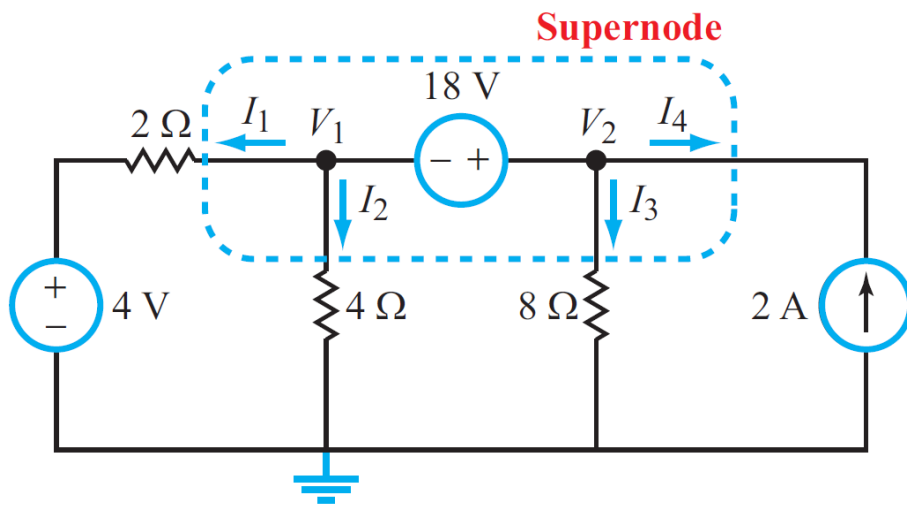
Solution:

Determine: V_1 and V_2

Example 3-3: Supernode

(Solution is introduced by the instructor in class)

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Determine: V_1 and V_2

Solution:

$$I_1 + I_2 + I_3 + I_4 = 0$$

$$\frac{V_1 - 4}{2} + \frac{V_1}{4} + \frac{V_2}{8} - 2 = 0$$

$$\Rightarrow 6V_1 + V_2 = 32 \quad (1)$$

$$\text{Supernode Eq.} \quad V_2 - V_1 = 18 \quad (2)$$

$$\Rightarrow V_1 = 2V, \quad V_2 = 20V$$

Optimum Learning Process

- **Before Class:** (1) Print a copy of PPT slides for the chapter (from Canvas) and place it in a 3-ring PPT binder. (2) Review material from last class , and look through the next 15 slides. (3) Make sure you have read the book sections assigned in the syllabus.
- **In Class:** Take notes and write observations on the hard copy of PPT slides, do not sit back passively.
- **After Class:** Add notes to your PPT binder, from memory and the book; to be effective, this should happen within 24 hours after the lecture.

Homework Assignments

Assignment	Due Date		Homework Problems
1	Mon.	9-14	1.1, 1.5, 1.9, 1.13, 1.14
2	Th.	9-17	2.1, 2.10, 2.14, 2.17
3	Mon.	9-21	2.19, 2.25, 2.28, 2.33
4	Th.	9-24	2.35, 2.40, 2.43, 2.47, 2.59
5	Mon.	9-28	2.66, 2.69, 2.77, 2.80
6	Mon.	10-5	3.5, 3.12, 3.20f, 3.22b, 3.36
7	Th.	10-8	3.44f, 3.51, 4.4, 4.10, 4.14
8	Mon.	10-12	4.20, 4.31, 4.36a, 4.44,

Homework

Two short homeworks per week,
instead of one long homework

Homework No. _____ Date _____

Name _____ Section 1(10:30am) _____

UMID _____ Section 2(1:30pm) _____

Quiz 1 on Day 1

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- 1. State at least three of the four fundamental forces of nature:
 - (a)
 - (b)
 - (c)

- 2. The wavelength of a light wave of frequency f travelling in vacuum is given by:
 - $\lambda =$

Keep them on their toes!!

Concluding Day 1

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- Clear message on expectations, rules, preparedness
- Quiz 1: gets their attention
- 3-ring binder

Teaching Approach

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- **Introduce** a new concept
- **Illustrate** solution through example
- Use a **typical HW Problem in class**
 - Give students 10 minutes to solve it
 - Go through the solution “together” by soliciting input

1:1 Meetings

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- Website signup
- 5-10 minutes
- Examples of Discussion Questions:
 - ❖ Where did you grow up?
 - ❖ Why did you decide on EE or CE?
 - ❖ Where do you see yourself in 5 years?
 - ❖ What questions do you have for me ?
 - ❖ -----

These are sample questions to get the conversation going with the student.

Your Question:

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- You might ask: How can the instructor find the time to meet with every student for 5-10 minutes, especially in large classes?

The answer is: for a class of 100 students, the 1:1 meetings require about 10-15 hours, which can be spread over 3 days during the early part of the semester, at 5 hours each. On the other hand, I do not allocate office hours, across the entire semester. That's the tradeoff! For technical questions or help to explain homework problems, the students are directed to the lab instructors, who **are** required to provide office hours. With 3 lab instructors, each providing 5 office hours per week, the arrangement provides the students 15 office hours per week, far more than the office hours that a typical instructor is willing to allocate. The arrangement is a win-win all the way around.

If a student would like to seek advice from me on subjects related to the course (but not on how to solve a problem), he/she is always welcome to stop by my office.

Learning the students' names



Before every class, I identify 2-3 students and I teach myself to associate the names with the faces. In class, I call on each of them and ask him/her a question. The students love the idea of connecting with them individually.

First Exam— **Very Important**

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- Share Sample Exam and Solution a week ahead
- In-Class Trial Exam
- Solution of In-class exam the very next day
- Real Exam (next slide)
- Meet with each student who scores below C
- Second-chance exam if warranted

Exams

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- Designed for **1-1.5 hours**, but the students are given **3 hours**
- Eliminate time pressure
- Each student is there to demonstrate how well he/she understands the material
- **Competing against own potential**, not against other students.
No curve.
- **Second-Chance Exam if warranted**
- **Grading**
- HW: Graders, returned by next class.
- Exams: Instructor, with help from TAs, returned by next class
- **Proctoring: I attend every exam, and I may offer a hint (very quietly so we do not disturb the rest of the students) when asked by a student who is stuck on a problem.**

After First Exam

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- I Invite each student who scored below 70 on the exam to come meet with me.
- If the student is so far behind that salvaging the course is unrealistic, I advise him/her to drop the course.
- For students where there's a reasonable chance that they can save the course, I arrange a special 2-3 hour session with them to drill through the material of the first exam.
- I announce that the final grade in the course will be the greater of the following two grades:
 - (1) The numerical sum of all exams, HW, etc. and
 - (2) Final exam grade alone.

The course grade should be the best measure possible of the level of understanding of the course material by the student.

Student Comments

- **Student 18:** It's not his impressive resume or the fact that he's written the books used in most of the prerequisite courses, but his dedication to the students that makes him stand out. Things like taking time to **speak one-on-one with each student.** He took time to offer an optional "redo" of the first exam—despite the fact that the average was rather high. It was apparent that the intent was to provide an incentive to those who had perhaps fallen behind to catch up with the class, and for many that's exactly what it did. He monitors the class, **knows who's attending and who isn't. Who studies and who doesn't.** It's this dedication to his students that makes Professor John D.T. stand out.

Student 18 Cont.

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- I also found it unique that he grades the exams himself. After an exam, I have friends express concern that their performance may not just affect their grade, but that they may have disappointed Professor John. This is a phenomenon I have never encountered before, but yet one that I completely understand as I have harbored the concern myself. Personally, I had a difficult time this semester, mostly resulting from a series of minor personal disasters that combined to rob me of the time I needed to devote to school. He doesn't know it, but his policies and the way he ran class were perhaps the only thing that kept me on track this semester, and I am immensely grateful.

Thursday Forum: Stories

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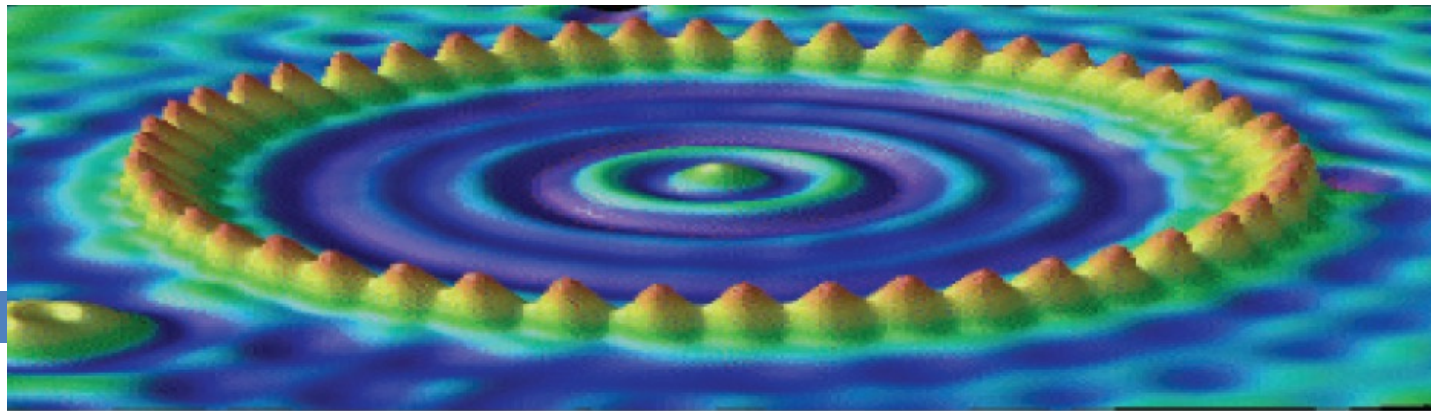
- Students suggest topics ahead of time
- Topics can range from course-related and career-related to almost anything
- Instructor decides which questions to address
- **Typical list of topics**
 - How is data rate related to bandwidth? What determines data rate?
 - How does a touch sensor work?
 - MS degree? Advantages/disadvantages?
 - Tell us about your research.
 - How is 5G different from 4G?
 - Use the story to break the monotony of the serious technical material

Undergraduate Teaching

- How do we make the learning of fundamentals in undergraduate courses:
 - a. *More relevant to daily experience?*
 - b. *Interesting, and extendable to real-life systems?*
- How can we take advantage of technology to integrate theory with hardware?
- The answer is: **Tech Briefs**

My Answer

- **Technology Briefs:** To bridge the gap between fundamentals and real-world systems
- **Interactive Simulation Modules:** To analyze and synthesize a variety of circuit/system configurations, often more elaborate than the simple examples treated in the book.
- **Hardware Interface:** To allow the student to construct circuits outside a formal laboratory.



List of Technology Briefs

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Technology Brief 5 Light-Emitting Diodes (LEDs)

How LEDs Are Made

LEDs are a specific type of the much larger family of semiconductor diodes, whose basic behavior we discussed earlier in Section 2-6. When a voltage is applied in the forward-biased direction across an LED, current flows and photons are emitted (Fig. TF5-1). This occurs because as electrons surge through the diode material, they recombine with charge carriers in the material and release energy in the form of photons (quanta of light). The energy of the emitted photon (and hence the wavelength/color) depends on the type of material used to make the diode. For example, a diode made of indium gallium aluminum phosphide (InGaAlP) emits red light, while a diode made from gallium nitride (GaN) emits bluish light. Extensive research over many decades has yielded materials that can emit photons at practically any wavelength from the infrared through ultraviolet (Fig. TF5-2). Various "tricks" have also been employed to modify the emitted light after emission. To make white light diodes, for example, certain blue light diodes can be coated with crystal powders which convert the blue light into a broad-spectrum "white" light. Other coatings such as *quantum dots* are still the subject of today's research. In a traditional package, the LED transmits light in a hemispherical pattern, but numerous other light-focused packaging methods are available that can focus the light in virtually any way imaginable. LEDs can be focused using highly reflective coatings to intensify their light for higher power applications.

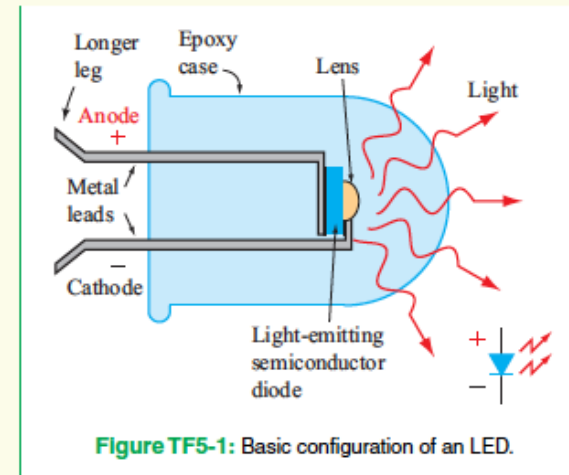


Figure TF5-1: Basic configuration of an LED.

In addition to semiconductor LEDs, a newer class of devices called *organic light emitting diodes* (OLEDs) are the subject of intense research efforts. OLEDs operate in a manner that is analogous to conventional LEDs, but are made from organic molecules (often polymers). Because OLEDs are lighter weight than conventional LEDs and can be made to be flexible, they have the potential to revolutionize handheld and lightweight displays, such as those used in phones, PDAs and flexible screens. Imagine a flexible contact lens that could allow you to see a heads-up display or augmented reality!

LED Advantages

LEDs have several major attributes that have made them a key element of many applications. First, they can be

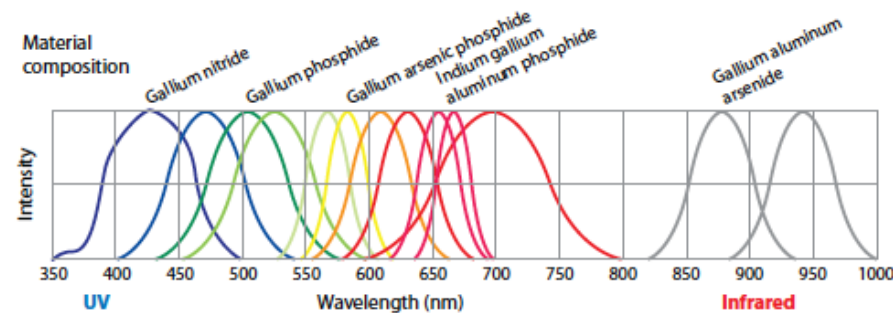


Figure TF5-2: Emission spectra of LEDs made of different material compositions.

Tech Brief 1: LED Spectra

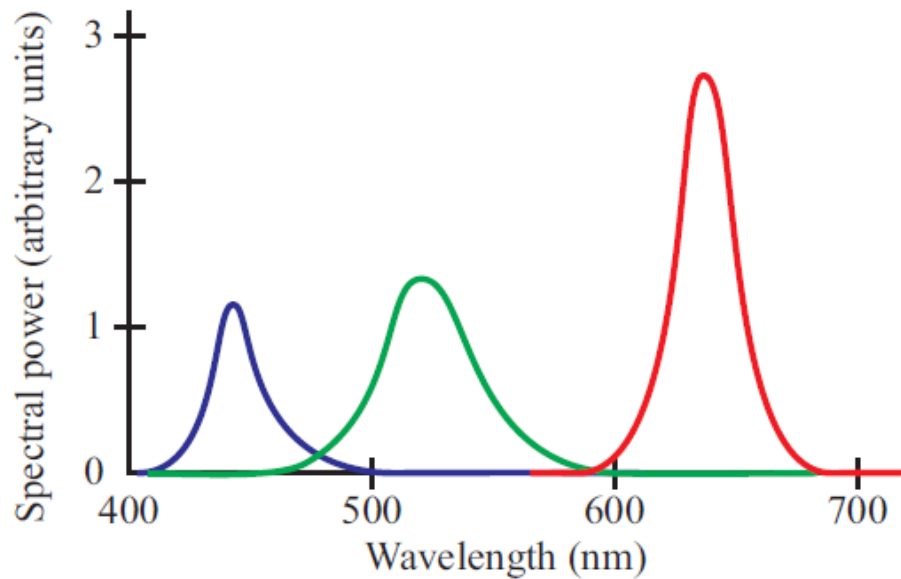


Figure TF1-5: The addition of spectra from three monochromatic LEDs.

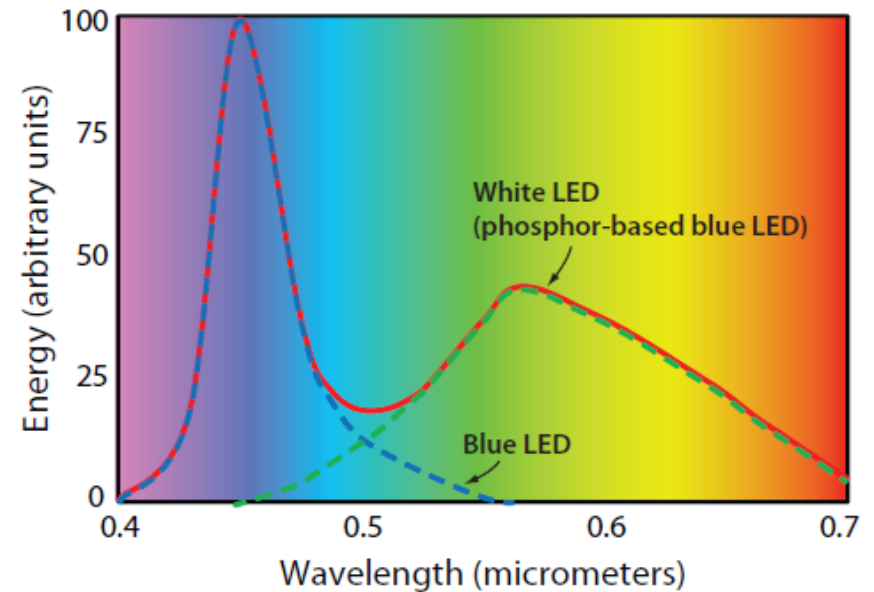


Figure TF1-6: Phosphor-based white LED emission spectrum.

Two ways to generate a broad spectrum, but the phosphor-based approach is less expensive to fabricate because it requires only one LED instead of three

Tech Brief LED Lighting



(a)



(b)



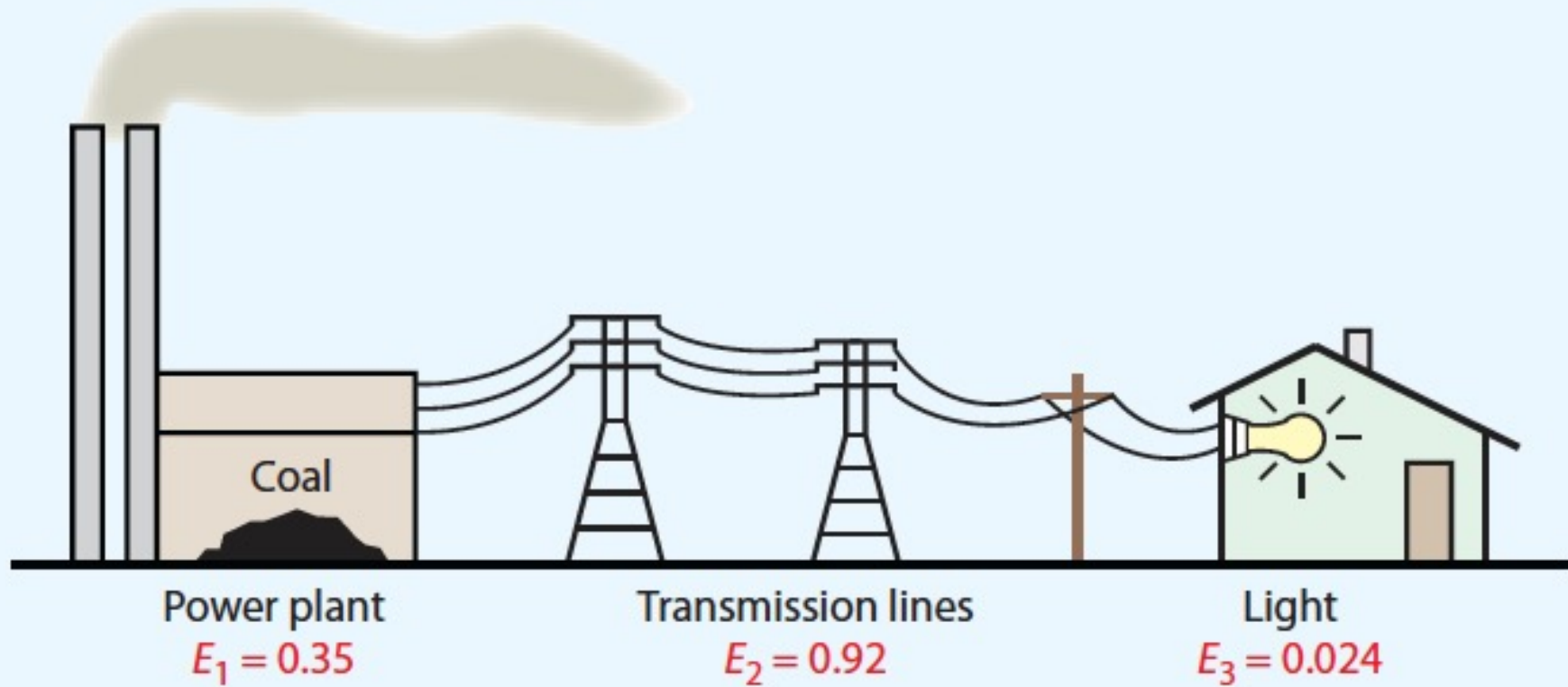
(c)

Figure TF1-1: (a) Incandescent light bulb; (b) fluorescent mercury vapor lamp; (c) white LED.

Incandescence is the emission of light from a hot object due to its temperature

Fluoresce means to emit radiation in consequence to incident radiation of a shorter wavelength

When a voltage is applied in a forward-biased direction across an LED diode, current flows through the junction and some of the streaming electrons are captured by positive charges (holes).



Overall efficiency for conversion of chemical energy to light energy is
 $E_1 \times E_2 \times E_3 = 0.35 \times 0.92 \times 0.024 = 0.8\%$

Figure TF1-3 Lighting efficiency. (Source: National Research Council, 2009.)

Tech Brief 1: LED Lighting Cost Comparison

Parameter	Type of Light Bulb			
	Incandescent	Fluorescent	White LED	
			Circa 2010	Circa 2025
Luminous Efficacy (lumens/W)	~12	~40	~70	~150
Useful Lifetime (hours)	~1000	~20,000	~60,000	~100,000
Purchase Price	~\$1.50	~\$5	~\$10	~\$5
Estimated Cost over 10 Years	~\$410	~\$110	~\$100	~\$40

Figure TF1-7: Even though the initial purchase price of a white LED is several times greater than that of the incandescent light bulb, the total 10-year cost of using the LED is only one-fourth of the incandescent's (in 2010), and expected to decrease to one-tenth by 2025.

Fingerprint Imager

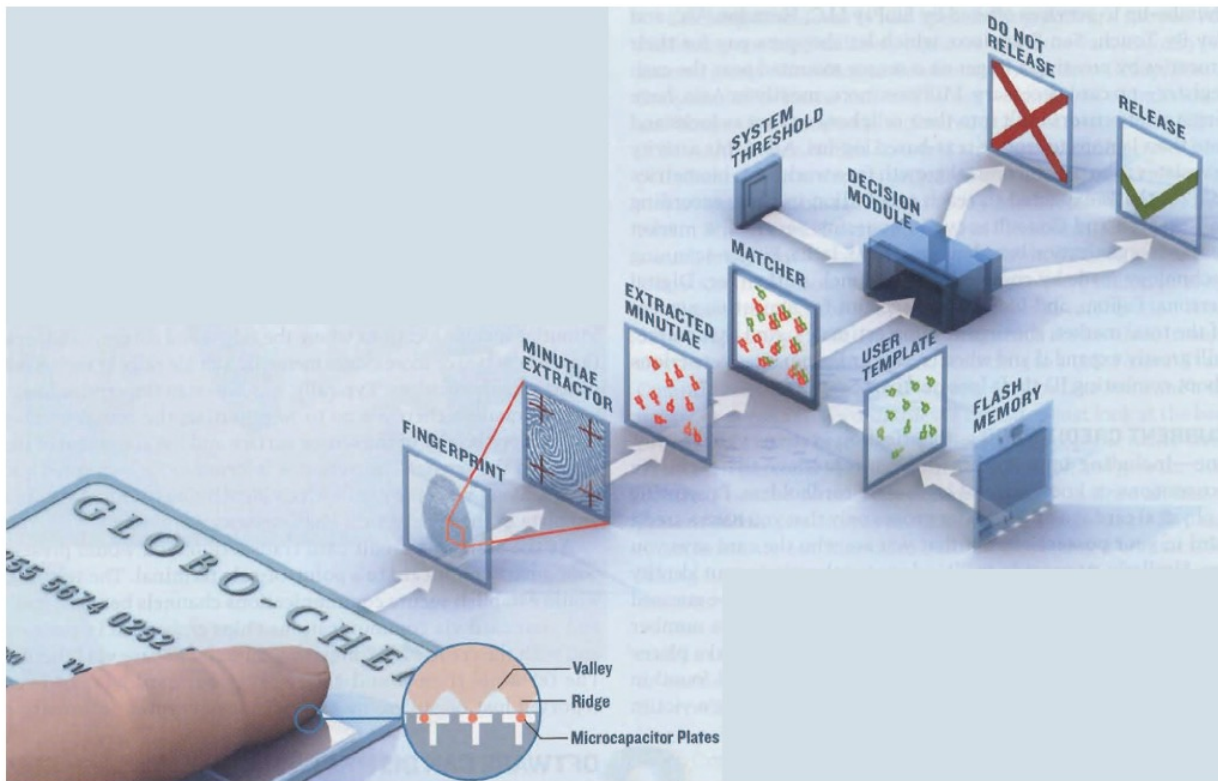


Figure TF9-6: Elements of a fingerprint matching system. (Courtesy of IEEE Spectrum.)

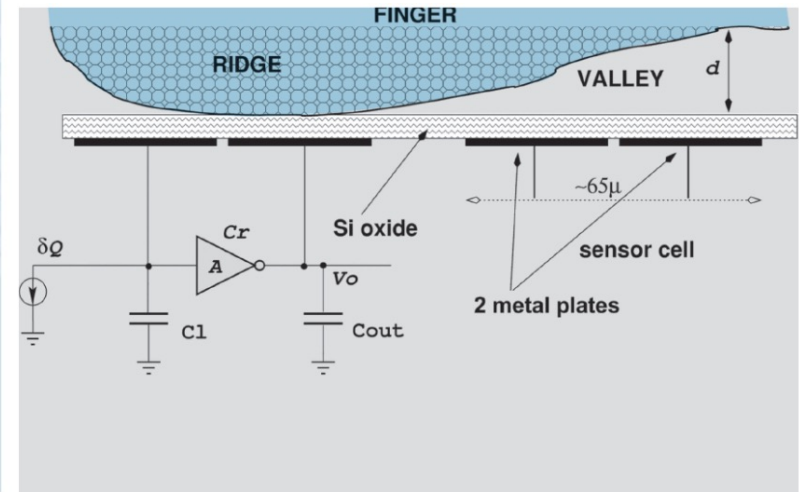


Figure TF9-7: Fingerprint representation. (Courtesy of Dr. M. Tartagni, University of Bologna, Italy.)

Design Projects: Built in their dorm rooms

- Security System
 - Audio Amplifier
 - AM Radio
 - Heart Rate Monitor
 - Knock Door Unlocker
 - Audio Equalizer
 - 3-D Tennis
 - Energy Harvester
-
- 116 out of 136 students participated in the optional project

Bottom Line:



- Use Tech Briefs to bridge the gap between fundamentals and real-life devices and systems
- Use software simulation tools (Multisim and Labview) to enhance the learning process
- Use hardware tools (MyDaq) to gain direct measurement and design experience

Above All:

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- **Connect** with the students in your class
- **Emphasize learning** over grades
- Help them become **disciplined professionals**

Our Role as Instructors

Teaching college students can be a very rewarding experience. Transferring knowledge to a new generation of professionals and teaching them how to work hard and instill self discipline is an important part of our responsibility as instructors.