CprE 288 – Introduction to Embedded Systems
(Syllabus & Course Overview)

<u>Instructor:</u>

Dr. Phillip Jones

Overview of Today's Lecture

- Announcements
- Syllabus
- Course Overview
- Warmup review

Announcements

- HW 1: Due Sunday (9/1)
- Quiz 1: Thursday next week, **using Canvas**
  - **Note: No materials or Calculator allowed for Quiz 1**
- **Labs start this week** (platform overview)
- Class website: http://class.ece.iastate.edu/cpre288)

SYLLABUS

Syllabus | Policies

- Laboratory
- Lecture
- Homework
- Academic Honesty
- Classroom Conduct

Syllabus | Laboratory Policy

- Lab attendance: is **mandatory**, unexcused absence results in a 0 for that lab
- Teamwork: labs are partner activities (no exceptions)
- Emergencies: inform instructor and your TAs **prior** to the start of lab
- Labs and a lab project (e.g. Solve a real-world problem)
  - Prelab, if given, must be completed before start of lab session
  - Lab demo is due at the beginning of lab the following week
    - TA will check them off during the first 5 minutes of Lab
- Location: All lab sections located in Coover 2041

Syllabus | Lecture Policy

- Lecture attendance:
  - In-class exercises are a component of your grade
    - Part of course participation grade
  - In-lecture activities are for reinforcing course content.
- Quizzes: Typically once a week a 10 minute Canvas quiz at the beginning of lecture.

Syllabus | Homework Policy

- Weekly assignments: To keep mind active and to reinforce lecture
- Collaboration: Study groups encouraged for enhancing learning
  - ALL collaborators must be documented on HW
  - Specifically what and how collaboration was done must be given
  - Copying and/or not specifying how collaborated is considered a violation of academic integrity (see syllabus for details)
- Typed: homework answers are required to be typed
- Submission: Use Canvas for HW submission (PDF or Word only)
- Late Policy: Homework can be turned in up to two days late for a **10% per day deduction.** **Homework given a 0 after this point.**
- Avoiding violations of Academic conduct: It is highly recommended that you first work through all problems on your own before collaborating with others to further improve you understanding.

Syllabus | Academic Honesty

- Exams/Quizzes: Work independently on exams/quizzes
- HW/Labs: Seek peer help to better your knowledge and skills rather than your grades
- **Do not borrow/copy code from others.**

- Example **good** questions to ask:
  - "Could you explain how pointers work?"
  - "I don't understand this io_t struct. What is it?"
  - "Can you explain successive approximation?"

Syllabus | Academic Honesty

- Examples of **bad** questions/actions that violate Academic Conduct polices:
  - "Can you show me your answer for question 3?"
  - "Can you e-mail me your homework?"
  - "E-mail me your source code for taking a Sonar measurements"
  - "If I do homework question 1, will you do question 2 and then we can trade?"

Syllabus | Academic Honesty

- The following acts are considered a violation of the University's student conduct policy (not exhaustive). Offenders will be reported to the Dean of Students Office. http://catalog.iastate.edu/academic_conduct/#academicdishonestytext
  - Sending or receiving any fragment of source code from another group, or from someone who previously took the class, is an offense.
  - Sending or receiving answers to homework assignments is an offense.
  - Copying answers to homework problems from others is an offense.
  - Copying answers from another person's exam is an offense.

- Infractions of academic honesty will result in a minimum of a zero on that assignment and may, at the discretion of the instructor, an F for the course.

Syllabus | Code of Classroom Conduct

- Code of Classroom Conduct summary
  - Treat all classmates in a respectful manner
  - Help ensure an inclusive learning environment
- Detailed Code of Classroom Conduct statement is found here: https://www.abe.iastate.edu/abe-code-of-classroom-conduct/

Syllabus | Grading Breakdown

- Exams 40%
  - Exam 1: 15%
  - Exam 2: 15%
  - Exam 3: 10%
- Quizzes: 10%
- Homework: 5%
- Class Participation: 5%
  - In class exercises
  - Reflections
- Laboratory Exercises: 25%
  - laboratory exercises
- Laboratory Project: 15%

Syllabus | Exams

- Exam 1 – TBA
- Exam 2 – TBA
- Exam 3 – TBA (Finals week)

This schedule is tentative

- What is allowed
  - Textbook
  - Datasheet
  - 1 sheet of notes (front and back) : 10pt+ font if typed.
  - Calculator

Course: High-level phases

Three general phases:

<u>Exam 1: (Microcontroller basics)</u>

- *~5 Weeks*
  - C for Embedded Systems
  - Interrupt handling (ISR)
  - Memory Mapped: I/O, Devices, Registers
  - Project Platform Basics

<u>Exam 2: (Microcontroller Peripherals/Devices)</u>

- ~6 Weeks
  - Serial (UART)
  - Distance sensors (IR & Sonar)
  - Analog to Digital Conversion (ADC)
  - Timers
  - Input Capture
  - Pulse Width Modulation (PWM)

<u>Exam 3: (Assembly)</u>

- *~3 Weeks*
  - ARM Assembly programming
  - Lab Project Demos

Course Overview| Course Learning Objectives

- Learn to interface microcontrollers with the real world
- Learn to enable others to interface microcontrollers with the real world
- Learn system-level debugging
- Learn the computing and data storage structure of microcontrollers
- Improve systematic learning
- Become familiar with professional roles in the embedded systems field

Course: Website

- Course website: http://class.ece.iastate.edu/cpre288
  - Primary source for course information, in addition to Canvas
    - Lecture slides
    - Lab descriptions
    - Useful resources
    - Homework posts
    - Detailed Syllabus information

COURSE OVERVIEW

Course Overview| Mindset

- Course structure will to a degree emulate a company
- You will be an entry level engineer in this company
- Through the semester you will:
  - **Define** a problem to be solved using an embedded system
  - **Train** on the company's embedded system platform and learn its technical capabilities and limitations.
  - **Prototype** a solution to your defined problem using the company's resources.

Course Overview| Embedded Systems Int. (ESI)

- Mission Statement: Embedded Systems International strives to combine engineering knowledge with embedded systems technology to solve a wide range of problems. As part of our charter, we place great value on communicating to the public at large the motivations for the projects we undertake, their inherent challenges, and their potential impact.

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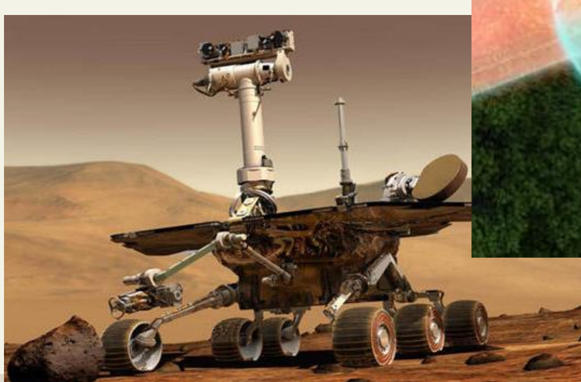

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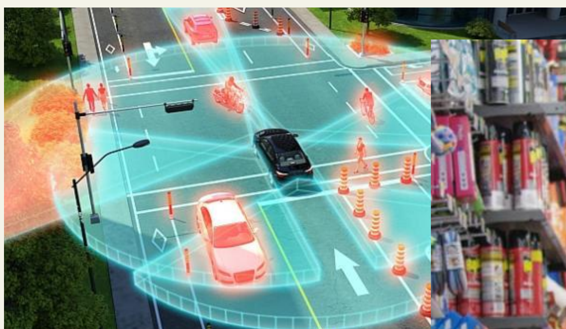

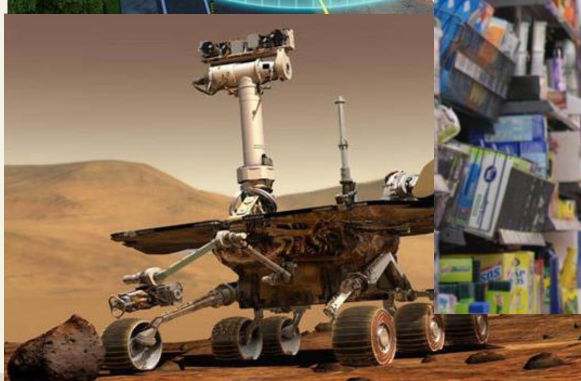

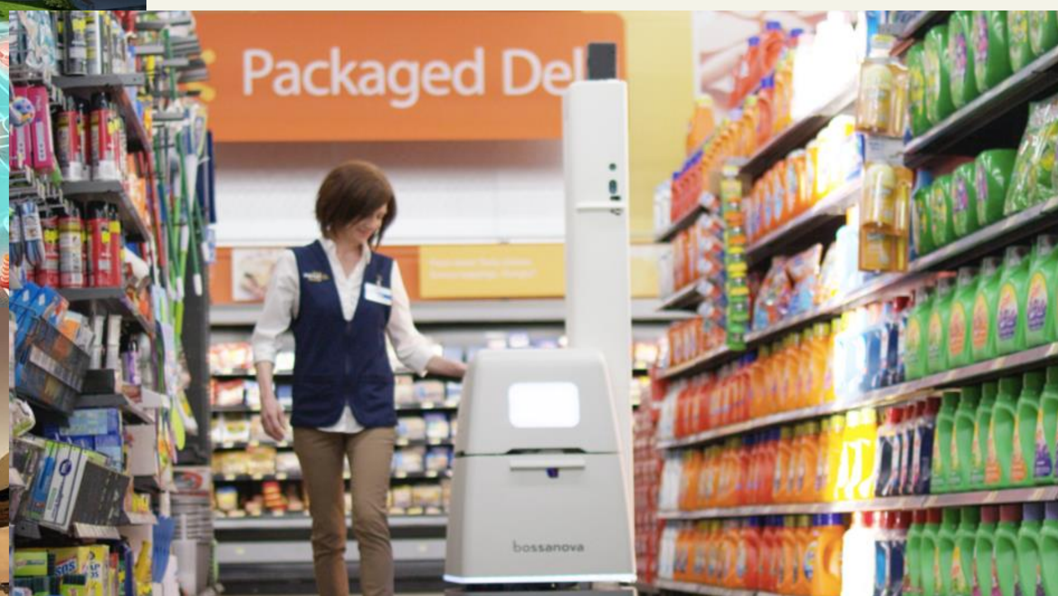

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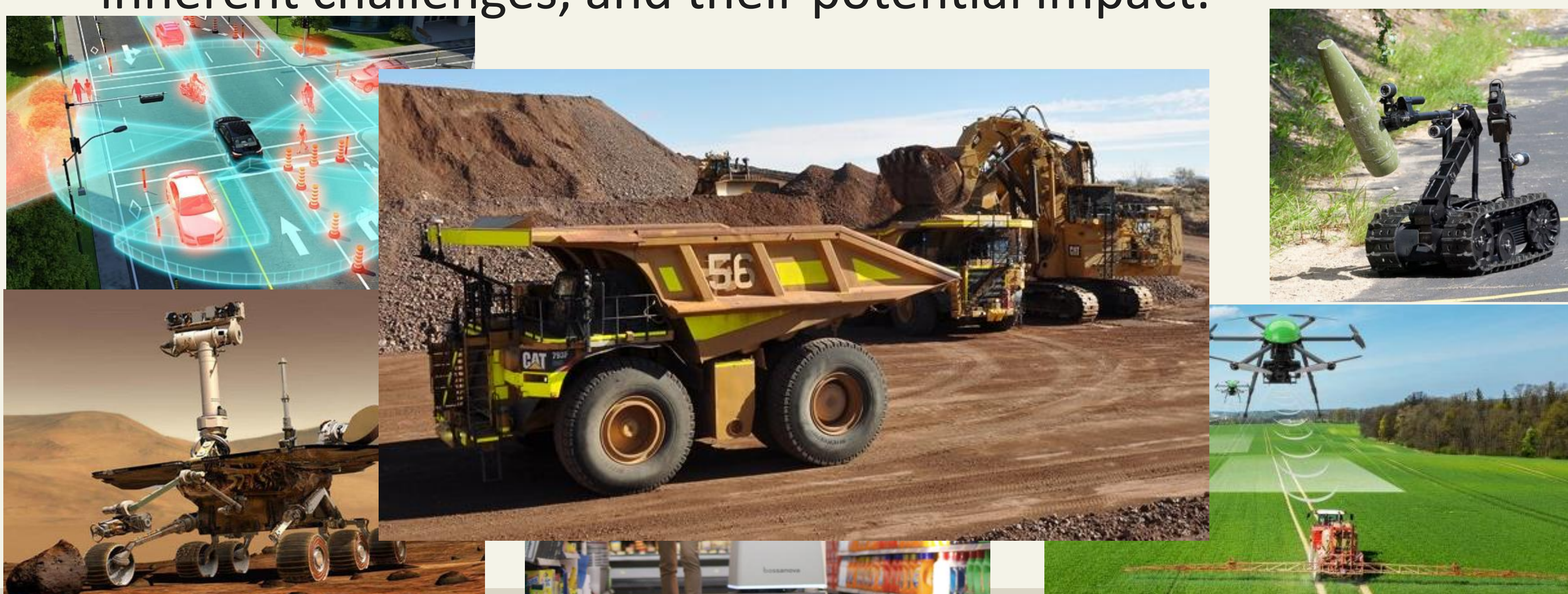

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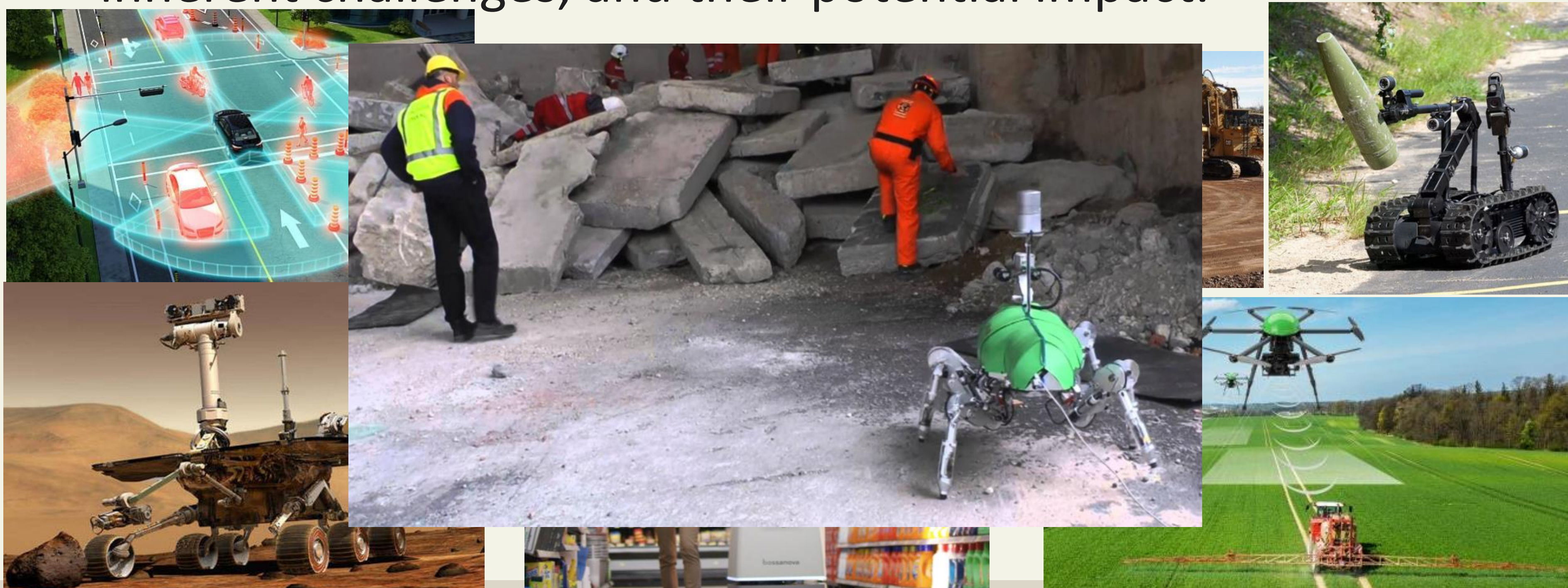

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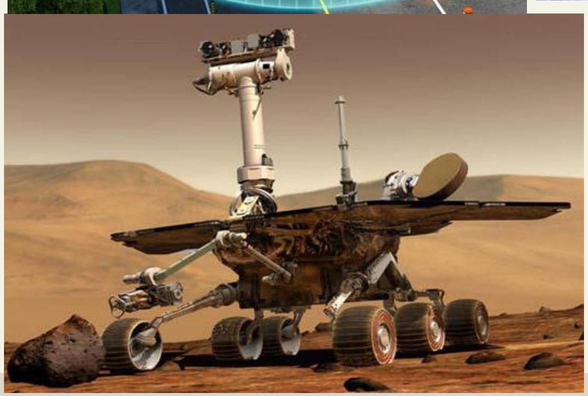

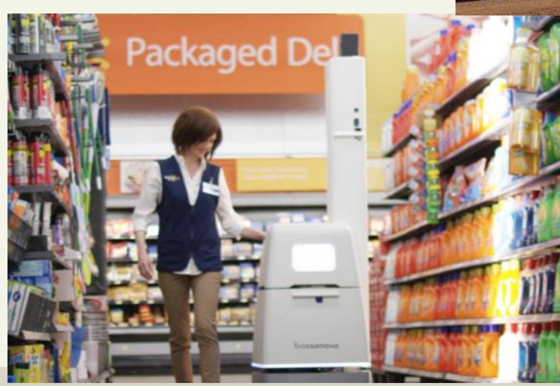

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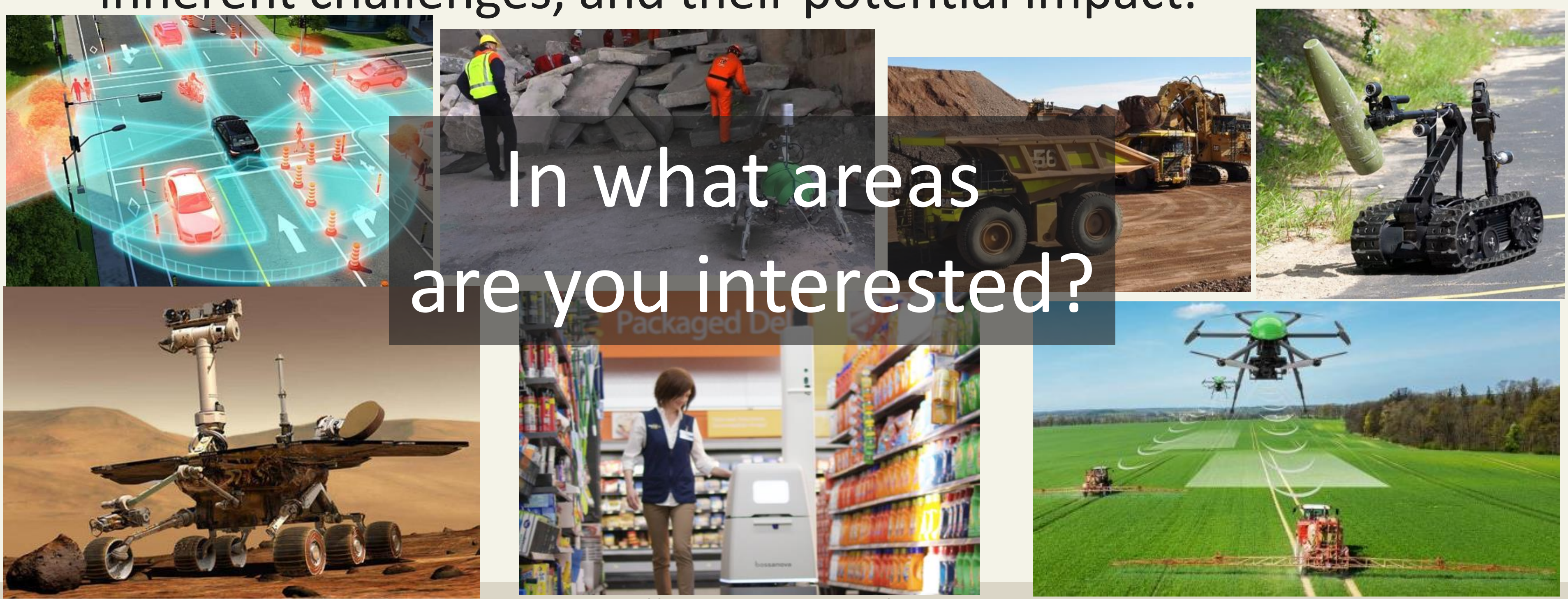

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- **Next 8 weeks:** You will be trained and will make use of the ESI development platform to prototype an embedded system product to solve a problem that could range from local to global societally scope.

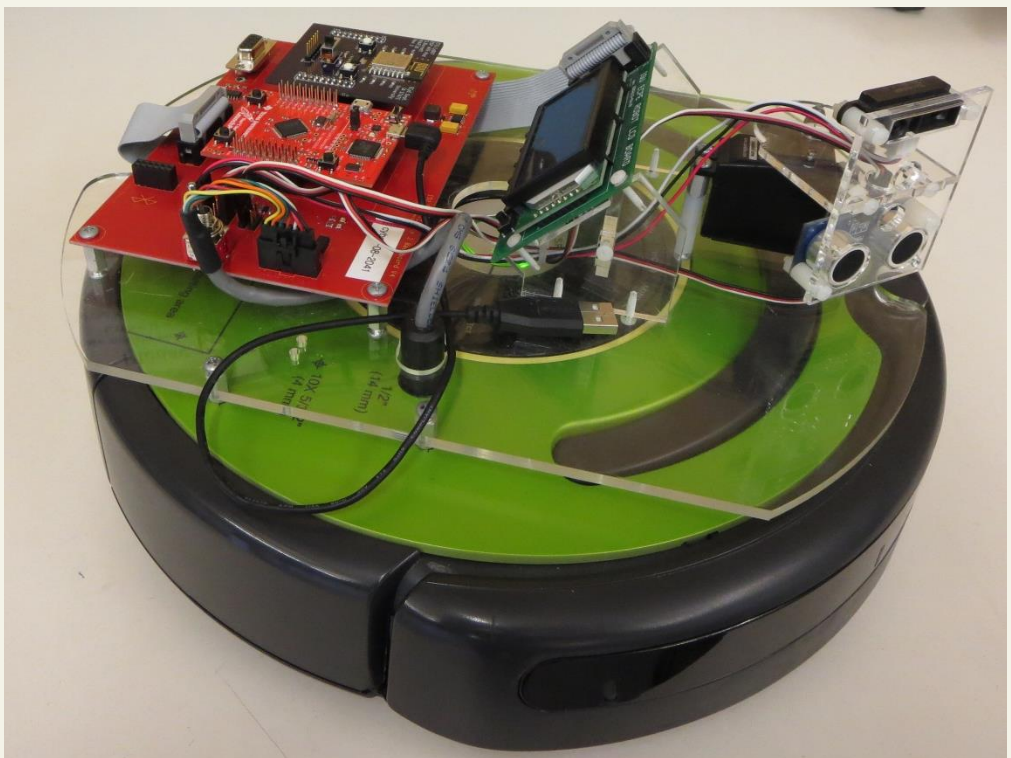
Course Overview| Employee Role

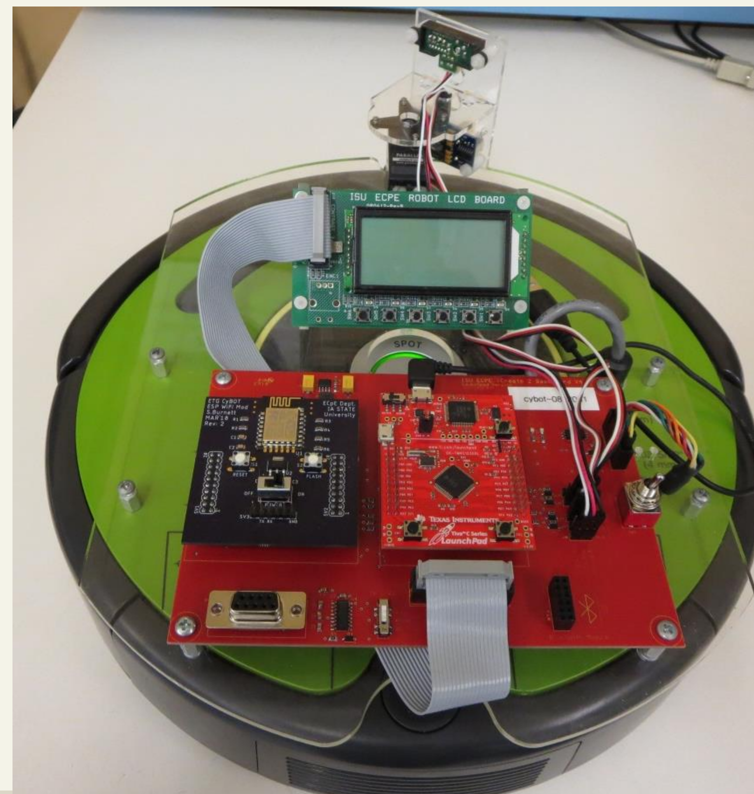
ESI has high expectations of our junior engineers. As a member of a team, you will be responsible for carrying out the following roles in your project:

- 1) gaining a clear understanding of what are the needs of your customer and the degree to which your solution addresses their needs,
- 2) learning how to use ESI's technology and gaining a clear understanding of the capabilities and limitations of the technology, and
- 3) prototyping your solution using ESI's technology.

Course Overview| Platform

CyBot: is the codename for ESI's embedded systems platform. It is a programmable mobile system composed of various sensors for solving embedded system problems





Course Overview| Typical week on the job

Each week you will be responsible for learning and applying an aspect of the ESI platform to enable you to implement a fundamental capability of your product.   This training process will involve you:

- 1) Reading and understanding the written documentation associated with a given aspect of the platform,
- 2) Attending training sessions related to that aspect, and
- 3) Demonstrating your proficiency in using that aspect through completing hands-on training assignments.

Course Overview| Example Problem

- Mars Exploration: NASA needs a way to investigate the surface of Mars.

- ESI solution: The Cybot platform will be used to develop a prototype of a Mars Rover that can:
  1) Avoid obstacles
  2) Collect data about the Martian terrain
  3) Stay within a radiation safe zone
  4) Navigate to a communication rely station to send findings back to Earth

- Prototype: [Fully Autonomous Mars Rover]

Course Overview| First Week Outlook

- What are you excited about?

- What concerns do you have?

Reflection Question

Take 2 minutes to think about and respond these questions:

- What is your view of the role of CPRE 288 in your curriculum objectives?
- What do you believe will be the biggest challenge in this class for you?

C IN EMBEDDED SYSTEMS

Methods for Representing Data

- Bit
  - 1 (True)
  - 0 (False)
- Nibble (less commonly used)
  - 4 bits
- Byte
  - 8 bits
- N-byte Words
  - 2-byte / 16-bit Word, 4-byte / 32-bit Word

Methods for Representing Data

- Three of the most common forms of notation
  - Decimal (base 10) 0123456789
  - Hexadecimal (base 16) 0123456789ABCDEF
  - Binary (base 2) 01
- Converting between forms
  - When converting binary to hexadecimal, every group of 4 bits (nibble) represents a hexadecimal digit
  - Examples:

Binary	Hexadecimal
0010	2
0100	4
1010	A

Methods for Representing Data

- Memorize conversion between decimal (0-15), hex (0x0 – 0xF), and binary (0000 – 1111).
  - This will be an important survival skill in Embedded Systems, similar to knowing your time tables up to 10x10 is important if you want to survive engineering.

Decimal (Dec)	Hexadecimal (Hex)	Binary (Bin)
0	0x0	0b0000
1	0x1	0b0001
2	0x2	0b0010
…	…	…
…	…	…
14	0xE	0b1110
15	0xF	0b1111

Base Conversion (by hand)

- Base n to base 10

Problem: Convert base 2: 0b0100_1011, to base 10

Solution:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128's	64's	32's	16's	8's	4's	2's	1's
0	1	0	0	1	0	1	1

64 + 8 + 2 + 1 = 75

Base Conversion (by hand)

- Base 10 to base n

Problem: Convert 175 to base 16

Solution:

Create a table of the columns in a base 16 number and subtract from the original number:

16^1	16^0
16's	1's
A	

175 – 160 = 15

16^1	16^0
16's	1's
A	F

Base in C

- Syntax in C
  - Computers understand binary
  - The following lines of code are all the same (the complier does not care what base the programmer uses):

```
char x = 2 + 1;
char x = 0b10 + 1;
char x = 0x2 + 1;
char x = 0x02 + 0x01;
```

END