Dr. John Wright
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Rm 111, Osburn Hall

Spring 2023 Office Hours:
Monday       1-3pm
Tuesday      1-3pm
Wednesday  1-3pm

Course Meeting Location/Times:
Rm 120/121/122
Monday/Wednesday 1:00-3:00pm

MILLERSVILLE UNIVERSITY
Department of Applied Engineering, Safety & Technology

**AENG 467 MOBILE ROBOTICS**
**3 s.h.**

## CATALOG DESCRIPTION

This course is a study of the development of mobile robotic solutions. Emphasis is placed on the programming and interfacing of microcontrollers to control autonomous mobile robots in known environments. A research and development activity is required.  2 hours lecture, 3 hours laboratory.  Prerequisite:  AENG 262 or permission of the instructor.

| _COURSE OBJECTIVES_  Upon successful course completion, students will be able to: | _ASSESSMENTS_  Students' achievement of course objectives will be assessed based on the following*: | | | | _PROGRAM OUTCOMES_  Program learning competencies for the AET(M), ARET, & MFET programs: |
|---|---|---|---|---|---|
| | LA | QU | EX | HW | |
| 1. **Explain** the origins of the personal computer and the microcontroller. | | x | | | A. Disciplinary Knowledge     An ability to **select and apply** the **knowledge**, **techniques**, **skills**, and modern tools of the discipline to broadly defined **applied engineering** activities. |
| 2. **Interface** microcontrollers to sensors and dc motor control circuitry to develop and control mobile robotic motion. | x | | | | |
| 3. **Assess** platform construction and design needs for given mobile robotic applications. | x | | | | B. Design     An ability to **design systems, components, or processes** for broadly defined **applied engineering problems** appropriate to program educational objectives. |
| 4. **Assess** and deduce sensing needs for a mobile robot and its environment. | x | | | | |
| 5. **Design** algorithms and **develop** programming techniques for various mobile robotic control issues. | x | | x | | |
| 6. **Design** algorithms and **develop** a complex control program for an autonomous mobile robot. | x | | x | | |
| 7. **Design** and **develop** a physical chassis solution (including sensor location) for an autonomous mobile robot. | x | | | | |

| 8. **Critique** current literature published on mobile robotics. | | x | E. Written Communication   An ability to **apply written communication** in both technical and non-technical environments. |
|---|---|---|---|
| 9. **Organize** and **develop** complete documentation for an autonomous mobile robot research and development project from conception to completion. | x | | |

*LA = Lab Experiment/Design Challenge; QU = Quiz; EX = Exam; HW = Homework/Papers.*

## CONTENT OUTLINE

   I. Historical Development and Applications
- A. Microprocessors/Personal Computer
- B. Microcontrollers
- C. Mobile Robots

   II. Programming Techniques
- A. Digital Input/Output Control
- B. Analog Input/Output Control
- C. Timing Delays
- D. Recursion
- E. Loops
- F. Subroutines
- G. Arithmetic
- H. Pulse Width Modulation
- I. Logic
- J. Multitasking
- K. Commenting
- L. Real time data acquisition and control

   III. Data Types
- A. Boolean
- B. Byte
- C. Integer
- D. Long
- E. Floating Point
- F. String

   IV. Platform Selection/Construction for Mobile Robots
- A. Mechanics/Locomotion
  1. Tracks
  2. Wheels
  3. Legs
- B. Platform Size/Shape
- C. Motor Selection
- D. Power Sources
- E. Speed
- F. Feedback
  1. Closed Loop
  2. Open Loop
- G. Steering Control
  1. Holonomic
  2. Non-holonomic

   V. Sensor Selection for Mobile Robots
- A. Contact
  1. Limit (Normal Open and Normal Closed)
- B. Non-Contact
  1. Infrared (IR)

        2.  LASER
        3.  Hall Effect
        4.  Pyroelectric
        5.  Ultra Violet (UV)
        6.  Sonar

    VI.  Interfacing Techniques for Mobile Robots
        A.  Sensors
        B.  Servo Motors
        C.  H-bridge DC Motor Control Boards
        D.  LEDs
        E.  Computers
        F.  LCD Displays
        G.  Actuators

## TEXT AND REQUIRED MATERIALS
Odom, C. D. (2020). Physical Computing & Robotics with the Arduino IDE, Volume One.

    http://www.lulu.com/spotlight/ChrisOdom

Odom, C. D. (2017). Physical Computing & Robotics with the Arduino IDE, Volume Two.
    http://www.lulu.com/spotlight/ChrisOdom


ANSI-approved safety glasses


## COURSE REQUIREMENTS
Students are expected to participate in or complete the following:

1.  Obtain the required text.
2.  Participate in class discussions.
3.  Complete and submit all required experiments.
4.  Complete a research and design experience.
5.  Satisfactorily complete all tests and quizzes.
6.  Participate in all assigned clean-up activities at the end of each class session and the close of the semester.
7.  Attendance is the responsibility of each student—assignments, experiments or other class activities carried on during any absence rests with the student.  An excessive number of absences will almost certainly be detrimental to your grade.  Attendance will be taken for the record.  A student's class attendance will be a factor in "letters of recommendation" requested by the student from the course instructor.  Attendance guidelines, as set forth by the Department of Industry and Technology, shall be followed.  This policy is included in this syllabus.

## EVALUATION
Course activities will be divided into the following categories:

A.  R&D Team Experience                                                                      60%
        1.  BUILD TIMELINESS (15% of Course Grade)
            a.  Navigation Checkpoint (5%)
            b.  Navigation + Detection + LCD Checkpoint (5%)
            c.  Navigation + Detection + LCD + Flame Extinguish Checkpoint (5%)

        2.  DOCUMENTATION (20% of Course Grade)
            a.  Project Description with Embedded Pics Required (5%)
                …includes a statement of the problem, the impact (importance) of the problem, objectives, procedure, results and conclusions.
            b.  Parts Listing (5%)
            c.  Process Flow Chart/Algorithm (5%)
            c.  Complete Programming Code with proper comments required (5%)

3.  FINAL PERFORMANCE TEST (25% of Course Grade)*
          3/3 Successful Runs = 25% A
          2/3 Successful Runs = 21% B
          1/3 Successful Runs = 19% C
          0/3 Successful Runs = 0-17.5% at Instructor's Discretion

*Robots that extinguish 3/3 candles are excused from the code exam (25/25)

| | |
|---|---|
| B.  Quiz (2 @ 5% ea.) | 10% |
| C.  Code Exam** | 25% |
| D.  Article Reviews (1) | 5% |
| E.   Bonus Article Review (2nd Review – use bonus form) | 3% |
| | 103% |

**Each student is allowed to use a single page (8.5"x11") hand-written command/code reference sheet. Proper flowcharting technique is also expected to be part of the exam.

Scale:

| | | | | | |
|---|---|---|---|---|---|
| 93.0 - 100 | A | 80.0 – 82.9 | B- | 67.0 – 69.9 | D+ |
| 90.0 - 92.9 | A- | 77.0 – 79.9 | C+ | 63.0 – 66.9 | D |
| 87.0 – 89.9 | B+ | 73.0 – 76.9 | C | 60.0 – 62.9 | D- |
| 83.0 – 86.9 | B | 70.0 – 72.9 | C- | 0 – 59.9 | F |

Should the end-of-semester mean score for the class fall below 75%, each student will receive a curve to fit the mean of 75%.

Grades will not be based upon criteria such as need, appearance, race, age, sex, or social status.  Once determined, grades will not be changed except in the case of clerical errors that cause the student's true level of ability to be underestimated.

## NOTES
The instructor reserves the right to alter this syllabus as required.

Late work (less than 1 week) will be subject to a 25% reduction in the student's earned grade.  All work submitted more than 1 week late will not be accepted and will result in a zero for the assignment.

Cell phones, PCs, and any type data storage devices or devices with cameras are **not** allowed for use on examinations.

## SAFETY PROCEDURES
A.  OSHA approved eye protection shall be worn by all individuals in the laboratory whenever activity is in progress.
B.  Smoking is not permitted during classroom activities (within the laboratory or outdoor sessions).
C.  Individuals shall not operate equipment unless they have been authorized by the instructor to do so.
D.  Tools and equipment shall not be removed from the laboratory.
E.  Be familiar with the location of all fire extinguishers, power disconnect buttons, and other safety equipment contained within the laboratory.
F.  Individuals should wash their hands with provided soap (laboratory sink) after handling solder.
G.  ALL accidents must be reported to the instructor immediately.

## STUDENTS WITH SPECIAL NEEDS
if you have a disability that requires accommodations under the Americans with Disabilities Act, please present your letter of accommodations and meet with me as soon as possible so that I can support your success in an informed manner. Accommodations cannot be granted retroactively. If you would like to know more about the Millersville University Office of Learning Services-please contact the office at 717-871-5554) ADA Program (Office of Learning Services) https://www.millersville.edu/hr/ada/index.php

**OTHER MILLERSVILLE UNIVERSITY POLICIES AND LINKS**
**Academic Honesty Policy link:**
https://www.millersville.edu/about/administration/policies/pdf/academics/academic-policyacademic-honesty-and-dishonesty.pdf ; for additional information please see the following:
https://www.millersville.edu/cae/teaching-and-learning/academic-integrity.php

**Attendance Policy link:** https://www.millersville.edu/registrar/faculty/attendance-policy.php

**Inclusion Statement:** https://www.millersville.edu/dsj/inclusionstatement/

**Land Acknowledgement:** https://www.millersville.edu/dsj/land-acknowledgement/index.php

**Policy on Delays and Cancellations link:** https://www.millersville.edu/delays.php

**Preferred Name FAQs link:** https://www.millersville.edu/dsj/inclusionstatement/preferredname-faqs.php

**Privacy Rights under FERPA link:** https://www.millersville.edu/registrar/ferpaforstudents.php

**Student Conduct and Community Standards Handbook link:**
https://www.millersville.edu/studentconduct/files/studentcodeofconduct.pdf

**Title IX Reporting Requirements and the Faculty member:** Millersville University is committed to maintaining a safe education environment for all students. In compliance with Title IX of the Education Amendments of 1972 and guidance from the Office for Civil Rights, the University requires faculty members to report incidents of sexual violence shared by students to the University's Title IX Coordinator. The only exceptions to the faculty member's reporting obligation are when incidents of sexual violence are communicated by a student during a classroom discussion, in a writing assignment for a class, or as part of a University-approved research project. Faculty members are obligated to report sexual violence or any other abuse of a student who was, or is, a child (under 18 years of age) when the abuse allegedly occurred to the person. Information about Title IX, resources and reporting can be found at:
https://www.millersville.edu/titleix/index.php

**ATTENDANCE POLICY**

**MILLERSVILLE UNIVERSITY ATTENDANCE POLICY**
*EFFECTIVE SPRING 2003*
*Approved by Faculty Senate 12/4/02; Administrative approval 1/10/03*

The University supports departmental and faculty class attendance policies that are reflective of and consistent with University approved guidelines.  Faculty will include their class attendance policy in their syllabi given to all students in their classes at the start of the semester.

**University approved guidelines:**
1.  **Students are expected to attend all classes.**  It is the student's responsibility to complete all course requirements even if a class is missed.  If a student misses class for an officially excused reason, then he/she is entitled to make up the missed work but only at the convenience of the faculty member.  Responsibility for materials presented in, assignments made for, and tests/quizzes given in regularly scheduled classes lies solely with the student.

2.  **The University policy is that faculty will excuse absences for the following reasons:**
    a.  personal illness,
    b.  death or critical illness in the family,
    c.  participation in a university-sponsored activity,
    d.  jury duty,
    e.  military duties, or
    f.  religious holidays

3. **Faculty judge the validity of student absences from class within the University's approved guidelines and may require documentation for excused absences.** Faculty will evaluate any reason, other than those listed above, for a student missing class and determine whether the absence is justified. In these circumstances, a student may make up missed work at the discretion of the instructor.

4. **In the case of foreseeable absences, students are encouraged to notify the faculty member in advance.** A student who will miss class due to participation in an official University activity must notify the instructor well in advance of the activity to assure that the absence is excused.

## Appeals:
As with any academic issue, students may exercise their right to appeal adverse attendance decisions. Please refer to the current undergraduate catalog for the complete Academic Appeal procedure.

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**AEST DEPARTMENT ATTENDANCE POLICY**
**Adopted May 4, 1998**

Students are expected to attend all scheduled classes in accordance with the above policy. To the extent that this does not happen, the following shall apply:

1. The limit of unauthorized absences depends upon the number of scheduled days per week as follows:
   <u>Fall and spring semesters</u>
   - three per semester for a course scheduled three days per week
   - two per semester for a course scheduled one or two days per week
   <u>Winter and summer sessions</u>
   - two per session

2. Each late arrival and early departure will count as one-half of an unauthorized absence.

3. Participation in outside-of-the-classroom educational activities and intercollegiate contests shall be communicated to the instructor prior to the absence. Failure to do so will convert these authorized absences to "unauthorized absences."

4. Students whose "unauthorized" absences exceed the policy stated in item #1 are liable to dismissal from the course with a grade of 'F' or 'Z.'

## BIBLIOGRAPHY
Bignell, J. W., & Donovan, R. (2007). *Digital electronics* (5th ed.). Clifton Park, NY: Thomson Delmar Learning.
Dixon, A. C., & Antonakos, J. L. (2000). *A practical approach to digital electronics*. Upper Saddle River, NJ: Prentice Hall.
Floyd, T. L. (2008). *Digital fundamentals* (8th ed.). Upper Saddle River, NJ: Prentice Hall.
Jones, J. L., Seiger, B. A., & Flynn, A. M. (1999). *Mobile robots: Inspiration to implementation* (2nd ed.). Natick, MA: A K Peters.
Lindsay, A. (2003-04). *Robotics with the Boe-Bot student guide v. 2.2.* Rocklin, CA: Parallax, Inc. www.stampsinclass.com
Lindsay, A. (2003). *What's a microcontroller? Student guide v. 2.0.* Rocklin, CA: Parallax, Inc. www.stampsinclass.com
Susneau, I., & Mitescu, M. (2005). *Microcontrollers in practice*. Berlin, Germany: Springer.
Tokheim, R. L. (2008). *Digital electronics: Principles and applications* (7th ed.). Columbus, OH: Glencoe/McGraw-Hill.

**AENG 467 Mobile Robotics Tentative Spring 2023 Schedule Ver. A**          **Wright**

| Week # / Week of | *M/W 1-3:00pm* |
|---|---|
| **1** <br> **1/16** | Course Introduction <br> T of N Video (PC Early History) |
| **2** <br> **1/23** | Introduction to the Microcontroller Lecture <br> Code Snippets PART I: Inputs Lecture <br> Code Snippets PART II: Outputs Lecture <br> R&D Project |
| **3** <br> **1/30** | Flowcharting Lecture <br> Code Snippets PART III: Serial Com – LCD Lecture <br> **Wednesday: Quiz #1 – T of N Video** <br> R&D Project |
| **4** <br> **2/6** | R&D Project |
| **5** <br> **2/13** | Introduction to the OpenMV H7 Machine Vision Unit: Detecting Color w/MicroPython Lecture <br> **Wednesday: Quiz #2 – Rules** <br> R&D Project |
| **6** <br> **2/20** | **Basic Navigation Checkpoint w/flowchart Due** <br> R&D Project |
| **7** <br> **2/27** | R&D Project |
| **8** <br> **3/6** | **No Class – Spring Break** <br> R&D Project |
| **9** <br> **3/13** | **Navigation + Occupant / Flame Detection Checkpoint Due** <br> R&D Project |
| **10** <br> **3/20** | R&D Project |
| **11** <br> **3/27** | R&D Project |
| **12** <br> **4/3** | **Unknown Factor Announcement** <br> **R&D Project** |
| **13** <br> **4/10** | **Navigation + Occupant / Flame Detection + Flame Extinguish Checkpoint Due** <br> **R&D Project** |
| **14** <br> **4/17** | R&D Project |
| **15** <br> **4/24** | R&D Project <br> **Wednesday: Final Robot R&D Test (Competition)** <br> **Robot documentation w/reflection Due – see syllabus for requirements.** |
| **Finals Week** | **Code Exam Wednesday May 3rd, 10:15am-12:15pm (Blue Book Required – Available in bookstore)** <br> **All Article Review(s) including Bonus Due** |