



Course Syllabus



Course: EE 599-001 (undergrads) / EE 699-001 (grads)

Title: Programmable Cameras and IoT

Term: Spring 2023

Credit hours: 3

Meeting days/time/location: Tuesday & Thursday, @ 12:30-1:45PM, in 107 Patterson Office Tower

Instructor Information

Name: Professor Henry (Hank) Dietz

Email: hankd@engr.uky.edu

Office building and room number: 203 Davis Marksbury Building

Office phone: (859) 257 4701

Office hours: schedule and live office camera are posted at <http://aggregate.org/hankd>
(<http://aggregate.org/hankd>)

Email is the preferred contact method; please place “**PCIOT**” in the *Subject* line.

Office meetings can be physically in the Davis Marksbury Building, or can be online via Zoom.

Although the threat from COVID19 is now significantly less than it was, it isn't gone, and course students and staff must abide by all relevant safety guidelines. Wearing a mask is not mandated, but be aware of potential exposures and take appropriate precautions. Use a mask or avoid meeting in person if you have reason to believe you might be contagious.

Course Description

This course will start by introducing the basic principles of photography and the details of how digital cameras work. However, cameras are no longer just about photography; they are sensors in embedded

computing systems that can serve a wide range of applications. For example, using CHDK, it is trivial to program a Canon PowerShot camera to serve as a non-contact tape measure. The course will use CHDK cameras, such as the SX530 HS, to explain how camera internals work and students will get hands-on experience using and programming these cameras. Cameras are also now cheap sensors for use within Internet of Things (IoT) devices. An ESP32-CAM IoT module that costs under \$10 includes a 2MP camera and can be programmed for tasks as diverse as wirelessly serving live video via an HTML browser interface to unlocking a door when a person's face is recognized. We will discuss IoT devices in general and use of the ESP32-CAM and its OV2640 camera in particular. Students will implement simple IoT projects using the ESP32-CAM via the Arduino programming environment.

Undergraduates should register for EE599-001, whereas graduate students should register for EE699-001. The key difference between the undergraduate and graduate students in the course is the scale of the projects and the requirement that graduate students must give a presentation of their advanced projects to the class. Graduate projects will also be more open-ended.

Course Prerequisites

Some familiarity with C, C++, or Arduino programming. No photography background is required.

Required Materials

Various materials for the course will be provided, primarily via canvas or the course website, [HTTP://aggregate.org/PCIOT](http://aggregate.org/PCIOT) ([HTTP://aggregate.org/PCIOT](http://aggregate.org/PCIOT)). There is no textbook per se.

Associated Expenses

Students will be loaned Canon PowerShot cameras for the duration of the course and will be given ESP32-CAM hardware. Ideally, each student should have a laptop that can support Arduino and CHDK programming.

Activities Outside of Regular Class Meetings

Class meetings generally will be in the assigned classroom, but some class meetings may instead be held either outdoors (e.g., capturing images) or as a "virtual flipped classroom" using Zoom to facilitate interactive sharing/debugging of code being written for the projects. There also are potentially useful facilities in the 108A Marksbury research lab.

Skill and Technology Requirements

Students are expected to have some C, C++, or Arduino programming experience and generally be computer literate.

For technical/account help, students can contact Information Technology Services by phone 859-218-HELP (4357) and via the [ITS Customer Services \(https://www.uky.edu/its/customer-support-student-it-enablement/customer-services\)](https://www.uky.edu/its/customer-support-student-it-enablement/customer-services) page. (<https://www.uky.edu/its/customer-support-student-it-enablement/customer-services> (<https://www.uky.edu/its/customer-support-student-it-enablement/customer-services>))

Student Learning Outcomes

After completing this course, a student will be able to:

- Describe the basic operation of a digital camera at the user level, as a photographer would use it [3]
- Describe the general design of digital camera hardware and lenses [1]
- Describe camera control algorithms for autofocus and other common operations [1,2]
- Write and run programs within a Canon PowerShot digital camera using CHDK [2,6]
- Write and run programs within an ESP32-CAM using the Arduino programming environment [2,6]
- Understand image data formats and computational postprocessing (JPEG, HDR, etc.) [1]

The 1-7 Computer Engineering Program Student Outcomes are listed at

<http://www.engr.uky.edu/about-us/accreditation/computer-engineering>

(<http://www.engr.uky.edu/about-us/accreditation/computer-engineering>) – each of the above course outcomes is marked with the most relevant program outcome number(s) in [].



Regular and Substantive Interaction/Academic Engagement

As per <https://www.uky.edu/tlai/compliance-faculty> (<https://www.uky.edu/tlai/compliance-faculty>), regular and substantive interaction (RSI) opportunities will be provided to ensure academic engagement even if portions of this nominally in-person course are taught using online mechanisms (e.g., due to pandemic-related issues).

Course Details

Tentative Course Schedule

- Introduction, overview of digital camera terminology and basic operation
- Basic photographic concepts and techniques; thinking like a photographer
- Introduction to CHDK, the Canon Hack Development Kit
- CHDK Lua scripting (camera apps)
- Control of camera operation (bracketing, motion detection, scripting, tethering, etc.)
- Image data (raw formats, EXIF, JPEG, etc.) and processing
- Introduction to the ESP32-CAM IoT and Arduino environment
- IoT camera applications
- Design of camera subsystems and lenses
- Camera algorithms (e.g., autofocus) and postprocessing
- Graduate project presentations and discussions

The precise topics and order of presentation is intended to be somewhat fluid, driven by the interests and issues encountered by students in the class.

Course Activities and Exams

There are two exams planned: a midterm and a final. However, these may be in a format that more closely resembles a lab practical rather than a conventional exam, with some part written and some part involving demonstration that you can perform specific tasks using the cameras provided. The final exam timeslot designated by the registrar is **10:30AM-12:30PM on Thursday, May 4, 2023**. These two exams will each count for approximately 15% of your grade.

10% of your grade will be allocated for class participation. This is a small class with a very hands-on experimental orientation, so students are expected to be active participants in class meetings.

The remaining 60% of your grade will be in assignments/projects. I expect there will be at least 5 assignments/projects, one involving basic photography, two using CHDK scripting to control a Canon PowerShot, and two involving Arduino programming of ESP32-CAM. Generally, projects will be submitted online. One CHDK project will be very simple using the camera to do something one wouldn't normally think of a camera doing; another will be automating a common photographic task. One ESP32-CAM project will be treating the ESP32-CAM essentially as a camera; another will be using the ESP32-CAM's OV2640 camera as a sensor to perform some action. **The key difference between the undergraduate and graduate students in the course is the scale of the projects and the requirement that graduate students must give a presentation of their advanced projects to the class. Graduate projects will also be more open-ended.**

We reserve the right to adjust the course activities and grading scheme should any unanticipated issues make it appropriate to do so. Students would be notified of any significant changes via canvas and/or the course web site.

Grading Scale

Nominally, the grading scale is:

90 – 100% = A

80 – 89% = B

70 – 79% = C

60 – 69% = D

Below 60% = E

Adjustments may be made to scores of specific graded materials (e.g., adjusting everyone's score for exam 0 if there was an issue with a question). Typically, any such adjustments will be in the student's favor.



Midterm Grades

For undergraduates, midterm grades will be posted in myUK by the deadline established by the University Senate and published in the [Academic Calendar](http://www.uky.edu/registrar/content/academic-calendar) (<http://www.uky.edu/registrar/content/academic-calendar>). (<http://www.uky.edu/registrar/content/academic-calendar>) . Note that midterm grades will be based on the work completed and graded up to that point, which do not necessarily have the same exam vs. homework ratio as the course overall. For this reason, the midterm grade may be computed by a different weighting formula than your course grade in order to better estimate your likely performance in the course as a whole based on the work done to that point.

Attendance Policy/Acceptable Documentation

This course counts class participation for 10% of your grade. Students are expected to regularly attend class and actively participate in discussions. The University of Kentucky generally expects appropriate documentation for an excused absence: e.g. a letter from a healthcare provider. In this course, we will generally be more flexible and notification beforehand via email to hankd@engr.uky.edu (<mailto:hankd@engr.uky.edu>), with “**PCIOT**” in the subject line, will be accepted as a valid reason for an excused absence. Students missing class meetings generally are responsible for catching-up on the material missed even if the absence is excused, although excused absences may be taken into account, for example, by extending project deadlines. Class presentation recordings will generally be made available to help those with an excused absence.

Assignment Policies

Assignment Submissions

All assignments will be collected electronically using software to be discussed in class and via canvas.

Returning Assignments to Students

Grades and comments on projects will be reported to students via Canvas. Contact the instructor if you would like more in-depth review of any of your coursework in person.



Late Assignments

Online exams and assignments are expected to be submitted no later than the specified deadline, but the server will accept late submissions. Except where University Senate Rules about excused absences apply, it is entirely at the discretion of the instructor as to how much, if any, credit will be awarded for a late submission. Late assignments that are submitted after the assignment answers are posted or discussed in class are given zero credit, but ones submitted before any answers have been made available are more likely to be given some credit. It is also useful to note that most assignments can be submitted multiple times without penalty, and all such submissions are typically logged, but generally, only the last one submitted before the deadline is considered for grading.

Assignments Due during Prep Week

No assignments will be due during Prep Week (which isn't really a week long). However, it is possible that activities making-up for an absence would be scheduled during that time.

Academic Policy Statements

Whatever is stated in the current Senate's [Academic Policy Statements](https://www.uky.edu/universitysenate/acadpolicy) (<https://www.uky.edu/universitysenate/acadpolicy>) document applies.

Academic Offenses (Cheating, Plagiarism, and Falsification or Misuse of Academic Records)

Whatever is stated in the current Senate's [Rules Regarding Academic Offenses](https://www.uky.edu/universitysenate/ao) (<https://www.uky.edu/universitysenate/ao>) document applies.

In the classroom, students should not take any actions that would disrupt the classroom environment (e.g., talking on a cell phone during class). In general, students are expected to behave in a respectful way towards their fellow students, the TA, and the instructor. **Failure to follow University of Kentucky**

guidelines involving appropriate precautions against spread of COVID19 or other communicable diseases will be treated as a very serious offense and dealt with as specified by the University.

Students are expected to generally behave in an ethical manner, but violations will be treated as serious offenses. Altering graded exams and then submitting them for regrade is obviously unethical, but you do not need to be trying to enhance your grade in order for your behavior to be inappropriate. For example, attempts to break into computer accounts associated with this course or to falsely identify yourself are serious ethical violations even if there was no intent to "cheat" per se.

There are lots of study materials for this course, including old exams, widely available; using them as study aids is perfectly acceptable, but be warned that an apparent reuse of an old question usually has the question slightly reworded so that repeating the old answer will get no credit. Although students are encouraged to discuss course material with one another, everything you submit must be entirely your own original work. Similarly, for in-class exams that specify no textbooks, no calculators, etc., use of the banned resources is a serious offense. Online exams will specify what is and is not permitted, but the general rule is that referencing your notes, looking at online materials at the course web site, etc. is OK – however, getting help from another human while working on an online exam is not OK. Neither is it permissible for you to offer such help to a classmate.

Resources

There are a wide range of resources available to help you with this course, the most relevant of which will be cited at either canvas or the course web site. There are also relevant facilities in Professor Dietz's lab, 108 Marksbury. Arguably the most important resources are the instructor and your classmates – and you are strongly encouraged to interact.

In addition, the University of Kentucky offers facilities/services such as [Distance Learning Library Services \(https://libraries.uky.edu/page.php?lweb_id=1020\)](https://libraries.uky.edu/page.php?lweb_id=1020) and [Tutoring and Coaching Resources \(https://www.uky.edu/studentacademicsupport/free-tutoring-and-coaching-resources\)](https://www.uky.edu/studentacademicsupport/free-tutoring-and-coaching-resources).

Diversity, Equity, and Inclusion

The Senate [Syllabus Statement on Diversity, Equity, and Inclusion \(DEI\) \(https://www.uky.edu/universitysenate/syllabus-dei\)](https://www.uky.edu/universitysenate/syllabus-dei) applies. Basically, I expect that we will all be open and nice to each other – that's what makes the best academic environment.



Student Resources

The University offers a variety of resources to students. Visit the University Senate's [Resources Available to Students \(https://www.uky.edu/universitysenate/student-resources\)](https://www.uky.edu/universitysenate/student-resources) to access that list .

Course Recordings

The University of Kentucky **Code of Student Conduct** (<https://www.uky.edu/studentconduct/code-student-conduct>) defines Invasion of Privacy as using electronic or other devices to make a photographic, audio, or video record of any person without their prior knowledge or consent when such a recording is likely to cause injury or distress.

Meetings of this course may be recorded. All video and audio recordings of lecturers and class meetings, provided by the instructors, are for educational use by students in this class only. They are available only through the Canvas shell or website for this course and are not to be copied, shared, or redistributed.

As addressed in the Code of Student Conduct, students are expected to follow appropriate university policies and maintain the security of linkblue accounts used to access recorded class materials. Recordings may not be reproduced, shared with those not enrolled in the class, or uploaded to other online environments.

If the instructor or a University of Kentucky office plans any other uses for the recordings, beyond this class, students identifiable in the recordings will be notified to request consent prior to such use. In anticipation of such cases, students may be asked to complete an “authorization of use” form by a faculty member.

Video and audio recordings by students are not permitted during the class unless the student has received prior permission from the instructor. Any sharing, distribution, and or uploading of these recordings outside of the parameters of the class is prohibited. Students with specific recording accommodations approved by the Disability Resource Center should present their official documentation to the instructor.



Course Copyright

All original instructor-provided content for this course, which may include handouts, assignments, and lectures, is the intellectual property of the instructor. Students enrolled in the course this academic term may use the original instructor-provided content for their learning and completion of course requirements this term, but such content must not be reproduced or sold. Students enrolled in the course this academic term are hereby granted permission to use original instructor-provided content for reasonable educational and professional purposes extending beyond this course and term, such as studying for a comprehensive or qualifying examination in a degree program, preparing for a professional or certification examination, or to assist in fulfilling responsibilities at a job or internship; other uses of original instructor-provided content require written permission from the instructor in advance.

Course Summary:

Date	Details	Due
------	---------	-----
