AMERICAN RIVER COLLEGE

ELECTRONICS DEPARTMENT

ENERGY 143

Solar Photovoltaic Systems Design, Installation, and Troubleshooting

Spring 2013

Course Title: **Solar Photovoltaic Systems Design, Installation, and Troubleshooting**

Course #: **19621** **Course Units:** 4

Instructor: Steve Geiger
Office hours TBA
Telephone number: 916-484-8354 E-mail: geigers@arc.losrios.edu

Prerequisite: ENERGY 141, Electrical & Mechanical Applications for Solar Installers and ENERGY 142, NABCEP Entry Level Test Review with grades of "C" or better

Hours: 54 hours LEC; 54 hours LAB

Class Times:

1/22 - 3/21	TuTh	09:00 AM	11:50 AM	Lec – Classroom: Tech Ed 322
1/22 - 3/21	TuTh	12:00 PM	02:50 PM	Lab – Classroom: Tech Ed 321

Course Description: This advanced course in solar photovoltaic (PV) energy offers the opportunity for hands-on experience designing, installing, and troubleshooting grid-tie and stand alone PV systems. Topics include hardware and software tools used in the solar PV industry, blueprint reading, calculating component size and capacity, and personal safety. Additionally, it covers calculating PV panel string sizing when working with grid tie inverters and battery sizing when designing stand alone PV systems. National Electrical Code (NEC) and fire code wire sizing, fusing, and other safety instructions and procedures are reviewed. Field trips are required. This course may be taken two times for credit using different hardware. 10 Hour Occupational Safety and Health Administration (OSHA) training provided. Students must pay the OSHA required fee in order to obtain the OSHA safety card.

Required Textbook: **Photovoltaic Systems (Second Edition), by James P. Dunlop, PE and the National Joint Apprenticeship and Training Committee (NJATC),** American Technical Publishers, (ISBN # 978-0-8269-1308-1)

Required **Solar Photovoltaic Systems Design, Installation, and Troubleshooting - Lab Project Packet**, Energy 143

Lab book: from University Press https://students.universityreaders.com/store/ or ARC Bookstore

RAD Requirement: Reading and retaining information in this course is a critical requirement for passing the NABCEP (North American Board of Certified Energy Practitioners) beginning installation test. Therefore, enrollment in RAD (Reading Across the Disciplines) to improve skills in reading studying, and retention is highly advised.

Required Materials: Approved Safety Goggles/Safety Glasses (they are required to be worn at all times in the lab)
A Scientific Calculator
All other Course materials will be furnished by the instructor

Recommended Materials: Notebook, binder for handouts

Student Learning Outcomes & Objectives:

Upon completion of this course, the student will be able to:

- assess safety hazards when working with photovoltaic systems.
- evaluate which types of solar photovoltaic panels are best in various PV installations.
- employ common hand tools in the mechanical installation of both a grid tie and a battery solar photovoltaic system.
- calculate the correct battery size for a stand-alone PV system.
- construct solar photovoltaic grid-tie systems.
- interpret blueprint drawings and what their symbols represent.
- calculate the Voltage and amperage of bi-modal PV systems.
- interface fuses, combiner boxes, and disconnects in grid-tie and stand alone PV systems.
- interpret NEC wiring codes for PV installations.
- calculate Voltage drops for short and long distances.
- calculate the maximum number of wires allowed in a conduit using NEC tables.
- describe the California Solar Incentives.
- troubleshoot and repair typical problems with solar PV systems.
- label all equipment and cable runs per NEC code.
- combine power generation sources for maximum coverage.
- identify new career paths in the solar power industry.

Evaluation Procedure:

Course Attendance	50 Points
Homework	125 Points
Lab Projects	125 Points
Portfolio of Projects	50 Points
Midterm/Final Exam/Oral Report/Project	150 Points
TOTAL	500 Points

Grading: The Final class grade will be based on a percentage of the total points (500) earned in the Course. Because of the complexity of the material, it essential to attend every class. See attendance policy (ARC) for grade lowering due to absences. (After two absences your grade is dropped one letter grade.) If the there is a problem with you missing a class, please contact me (leave a message) before the class to make other arrangements. All assigned lab projects must be completed for the student to earn a passing grade.

90%-100%	= A
80%-89%	= B
70%-79%	= C
60%-69%	= D
Below 60%	= F

Final: Thursday, March 21, 2012 Time: 9:00 AM – 2:50 PM

Field trip: A field trip is required and may be done at any time during the semester depending on tour availability. It will be during class time to allow those with other commitments to attend.

Dropping Classes: It is your responsibility to drop this course if you quit attending class. I will not drop you. Because the grading system is computerized, instructors are required to assign a letter grade for all students. Therefore, it is EXTREMELY IMPORTANT that you drop the class before the drop date so you won't receive an "F" on your transcripts. The drop date can be found in the college schedule.

ENERGY 143 Course Rules and Requirements:

Attendance Requirements – 2012-2013 Catalog:

(a) Per LRCCD Policy P-2222, students are expected to attend all sessions of the class in which they are enrolled.

(b) A student may be dropped from any class when that student's absences exceed six percent (6%) of the total hours of class time.

(c) Any student who is a no show shall be dropped from a class (CA Code of Regs., Title 5, 58004).

Note: Instructors must state in the class syllabus what constitutes excessive absences for that course.

Tardiness Policy:
The college does not have an official tardy policy. If the instructor wishes to implement a tardiness policy, it needs to be clearly stated.

Conduct and Behavior: Every college class is a learning environment. The college promotes and nurtures a safe environment for the free exchange of ideas and open expression of individuality and diversity within the bounds of courtesy, sensitivity, civility and mutual respect. The college practices the fundamental belief that every student has the right to a safe and respectful learning environment. Students should behave appropriately in class and show respect for classmates and the instructor. Examples of unacceptable behavior are yelling, moving about the classroom, talking during lectures or students presentations. The college prohibits sexist or racist remarks, and harassment of any kind. Students must turn off cell phones and other electronic devices during class. Students should not use I-Pods during class. Students should not wear headphone devices during class. Food and drinks are not allowed in classrooms.
Inappropriate behavior of any kind will be reported to the ARC Student Discipline Officer. Disruptive students may be suspended from class and are subject to more severe college disciplinary action, up to and including dis-enrollment, and suspension from the college. Any days spent in suspension from class are unexcused absences.
.

Plagiarism: Material submitted by the student shall be created by that student. Any plagiarized or copied material will not be counted for credit and receive 0 Points for that assignment.

Special Needs, Health and Safety: "Students with health issues or disabilities that may necessitate intervention, academic accommodations, or modification to the college educational or physical environment are encouraged to arrange an appointment to discuss these issues with the professor so that a plan for meeting these needs may be established (Heath Center, March 2004)". DSPS# 484 8545 (Disabled Students and Services) provide support services to students who are identified by them as needing accommodations. Latex products may be used. If a student has a health issue related to latex, the student should discuss with the instructor so that accommodation can be made.

Personal Protective Equipment and Clothing: Safety glasses will be worn during the lab portion of the class whenever performing dangerous activities such as soldering and cutting/ stripping wires.

Safety: All students must successfully complete a safety test with a passing grade before using lab equipment and tools, or working in the lab. All injuries must be reported to the instructor immediately. A safety review will be done prior to working in the lab.

Lab Clean-Up Policy: Students are responsible for cleaning up their work station and surrounding area and returning tools and supplies to the tool room at the end of each class session. Under no circumstances try to attempt to repair lab test equipment.

Field Trips: Students must sign the "Agreement to Participate and Waiver/Assumption of Risk" Form and submit to the instructor in order to participate in each field trip. The instructor will retain a signed copy of each form and submit a duplicate set of forms to the dean's office.

Homework is due one week from the day that it is assigned.

Tests and Quizzes: Quizzes that are missed must be made up prior to the next class meeting unless prior arrangements have been made.

Late Work: All materials to be graded must be submitted on the date due unless prior arrangements have been

made. Late assignments loose 10% per week after due date.

Reading Assignment(s): In addition to the handouts, there will be supplemental reading and web assignments required.

Outside Assignments: Homework assignments are required as part of your grade.

Health Issues or Disabilities: "Students with health issues or disabilities that may necessitate intervention or modification to the college educational or physical environment are encouraged to arrange an appointment to discuss these issues with the professor so that a plan for meeting these needs can be established. (Heath Center, March 2004)".

Supplemental Items: If you have an issue that requires special accommodations, let me know as soon as possible. There are many services on campus to assist students with their learning experience. It is recommended to seek help as early as possible when a problem arises. We can't help you if you don't ask.

Student Conduct Policies: Disruptive and inappropriate behavior will not be tolerated and may result in you being dropped from the class. Group learning is recommended; however, the lecture and lab tests are designed to test your individual knowledge of the material. So that means DON'T CHEAT!

Final and Progress Grades: Final grades will be available by college website or e-mail only. Grades will not be posted. Progress points will be available from the instructor and will be occasionally distributed.

Binders: It is a good idea to get a binder to keep the many handouts that you will be getting throughout the class. They are important and will be used as reference throughout your electronics career or can be sold at an exorbitant price on e-bay.

Methods of Instruction: The course material will be delivered by lecture, overheads, videos, textbook, supplemental reading and web-based assignments. Practical applications will be explored during hands-on demonstrations.

Cell Phones & Pagers: Phones and pagers interrupt the class and annoy fellow students. Please be considerate of others or they will be banned from the lab and lecture.

Food & Drink: **Food and Drinks are NOT** allowed in the Lab. Under no circumstances bring any food or drink into Room 323 because of Fiber Optic contamination of your food/drink.

Injuries: Notify the Lab Instructor immediately in case of injury.

Attendance Cessation: If you stop attending, it is your responsibility to contact e-services and drop the class. That way, the class will not be reflected on your transcripts.

Other Important Information: If you stop attending, it is your responsibility to contact e-services and drop the class. That way, the class will not be reflected on your transcripts. Use of appropriate language and sense of community—if behavior is disruptive to the class or the learning environment it is inappropriate. Latex products may be used in certain classroom activities. If a student has a health issue related to latex, the student should discuss with the instructor so that accommodation can be made.

- College Emergency Number is College Police at X2221 and from a cell phone at 558-2221
- All injuries must be reported to the instructor immediately.
- Safety glasses must be worn at all times when in the Lab (This is school policy)
- No food or drinks are allowed in the 323 Lab because of safety reasons (Fiber in your Coffee??) This means leave your backpacks, drinks and food someplace else!
- No playing around in the lab because of the cost of the equipment and safety issues

Final Comments / My Objective:
This instructor is pleased to accept suggestions regarding ways the class, labs, lectures, etc. may be made more fun, interesting, meaningful, and/or useful. Even though the essential content and required effort of the course cannot be diminished, all such suggestions will be carefully considered.

As your instructor, it is my objective to teach you the material in a dynamic and positive environment, as well as from personal first-hand experience. I like to teach in a synergistic and solution-oriented style. Your own motivation will help you succeed and excel in this class. I wish you the best for this semester.

Solar Photovoltaic Systems Design, Installation, and Troubleshooting
ENERGY 143
Semester Topic Outline
(May be modified due to semester time constraints)

Lec	Lab	Topic
3	2	Lecture: Review syllabus and outline for course, what we are going to study this semester, overview of solar power systems, tool and equipment familiarization, safety test and safety overview for PV solar equipment. Lab: Break into lab groups, tool and equipment familiarization, equipment safety demonstrations.
2	2	Lecture: Future trends in solar careers. Lab: Internet research on emerging and current careers in the solar industry.
4	4	Lecture: PV module factory specifications, PV panel Voltage vs. temperature responses and curves, families of PV cell structures and their applications, types of PV modules and their applications, how and why solar panels are connected in strings, choosing the correct module for a given application, mechanical design specifications for PV panel mounting hardware, pole mount arrays, ground mount arrays, typical solar PV panel installation mistakes and how to avoid them. Lab: Prepare and install pole mount solar system, ground mount, and common errors in PV mechanical installation.
3	3	Lecture: Roof structures including flat top roofs, commercial roofs, residential roofs, tile roofs, composition shingle roofing, shake roofs, blueprint drawings and what symbols represent, and the importance of being able to read blueprints and make professional modern drawings. Lab: Use Google “Sketch Up” software drawing program to draw a typical installation, installation procedures for solar panel roof racks, interpret blueprint drawings from actual commercial and residential buildings, modify actual blue print drawings to include solar PV system installation, importance of being able to interpret blueprints and make professional modern drawings, start drawing plans for our mock roof.
3	4	Lecture: Operation of grid tie PV systems, major components of a grid tie systems and their functions, review of inverter operation and different configurations, 12, 24, and 48 Volt and higher PV panels applications, sizing for different voltage PV panels, split voltage panels and inverters, Bi-modal systems, calculation of maximum Voltages and Currents. Lab: Calculate and measure maximum current using manufactures specifications, calculate and measure maximum Voltage using manufactures specifications, calculate load analysis for a residence after applying energy saving technology.
3	3	Lecture: Fusing specifications, laws and rules for PV panels and systems, understanding and specifying low and high Voltage AC and DC disconnects, understanding and specifying low and high Voltage AC and DC combiner boxes, interfacing fuses, combiner boxes, and disconnects in grid tie and stand alone PV systems. Lab: Assemble fuse blocks and calculate fuse and wire sizes, assemble combiner boxes and calculate wire sizes and interconnections for various loads, assemble disconnect boxes and calculate wire

		sizes for various loads.
3	3	Lecture: Apply load sizing software and applications to PV systems, specifications and applications of wiring junction boxes, calculating AC Voltage drops for short and long distances, calculating DC Voltage drops for short and long distances, National Electrical Code (NEC) fire codes, NEC wire sizing codes, conduit temperature restrictions, number of conductors allowed in a conduit. Lab: Wire junction boxes for solar panel application, calculate, build, and measure Voltage drops for low Voltage circuits, NEC wire practice calculations, fire code practice calculations, calculate internal temperature for various sizes of conduit at different ambient temperatures.
2	2	Lecture: Determining proper conductor sizing using the NEC tables for Amperes and temperature, fire code conduit sizing, maximum number of wires in a conduit, grounding applications for solar PV applications, ground Fault Interrupter (GFI) applications and limitations, low Voltage disconnects and their placement. Lab: Grounding of PV systems, GFI installation, wire low Voltage disconnect, calculate and install the maximum number of conductors in various sized conduits.
4	4	Lecture: Applications of high Voltage disconnects, electrical integration to grid tie interconnect systems, electrical integration to battery powered stand alone systems, battery sizing, battery maintenance and safety. Lab: Connection of high Voltage disconnects, battery sizing sample applications, measuring current and Voltage during battery charging and discharging, calculating maximum battery short circuit current.
3	2	Lecture: Operation of standby power systems, split systems, and inverters. Lab: Apply stand-by power systems, connection of inverters.
3	3	Lecture: Understanding the point of utility connection, grid tie interconnect agreements, AC connection with the meter box/distribution panel, fusing the AC connection, permit process with SMUD, PG&E and other local utilities, city and local jurisdiction permits, three phase power and where it is used. Lab: Assemble roof structure, assemble bottom of roof assembly, framing the actual roof, bracing -- how much is needed and where, safety when working on roofs, point of utility connection, AC connection at the meter box breakers.
2	3	Lecture: Operation of bi-modal PV solar systems, disconnects and power connections to the meter box, who owns what, auxiliary power systems including gas, propane, and diesel power generation, wind power generation, water power generation, combining power generation sources for maximum coverage. Lab: Apply roofing material to roof structure, attach PV racking hardware to roof, attach conduit and GFI to building, wire PV panels to each other and to the grid tie inverter.
1	2	Lecture: Marking and labeling equipment and PV panels to meet NEC compliance, testing the PV components, testing the entire PV system, differences between grid tie testing and stand alone system testing. Lab: Attach panels to the roof structure and racks, install battery systems, grid tie systems, label all equipment and cable run per NEC code, test individual components for operation, test entire

system for operation.

2	4	Lecture: Perform system check out and initial commissioning, performance proofs and why they are important, California acceptance testing, life cycle of solar PV systems, failure of components and equipment. Lab: Perform roof testing, panel sun blockage, different shading scenarios for various roof locations, install and remove PV panel blocking diodes to see effect, system testing and proofs, required testing for California solar incentives.
2	2	Lecture: PV system life expectancy, what can go wrong with a PV system, typical problems with PV system installations, mechanical problems, electrical problems, environmental problems, equipment failures. Lab: Perform comprehensive testing on the PV system, roof troubleshooting, simulated problems in PV systems, disassemble entire roof assembly, disassemble all PV trainers, review of semester lab projects.
1	3	Lecture: SMUD field trip to see distributed power generation system. Lab: SMUD field trip to see distributed power generation system.
4	0	Lecture: Intro to 10 Hour Occupational Safety and Health Administration (OSHA)safety card.
3	0	Lecture: OSHA training on fall hazards, electrocution, struck-by, caught-in, and between material dangers.
1	3	Lecture: Fitting and adjustment of personal protective equipment. Lab: Fit and adjust personal protective equipment.
2	1	Lecture: Health hazards present in the construction industry. Lab: Use and capabilities of personal protective equipment.