



UNIVERSITY OF PUERTO RICO
MAYAGÜEZ CAMPUS
COLLEGE OF ENGINEERING
INDUSTRIAL ENGINEERING DEPARTMENT



COURSE SYLLABUS

General Information

Course Number: ININ 4050 (**free elective**)

Course Title: **Printed Circuit Board Assembly**

Credit-Hours: Three

Course Description

The course explains the basic manufacturing requirements of Surface Mount and Through hole technologies. Lectures will include a description of processes, required tooling, underlying scientific principles behind the processes, use of mathematical models, and an understanding of how independent variables impact the quality of the final product.

The objectives of the laboratory are to provide students with hands-on experience with surface mount processes and to provide the opportunity to implement improvements and define all process parameters to populate printed circuit boards.

Students who complete the course successfully become candidates for participating in PCB manufacturing activities for possible outside customers. For this reason, students should have 3rd or 4th year standing. A limited number of seats will be provided to participating departments, and a class section should not have more than 18 students registered.

Pre-requisites

CHEM 3002 – General Chemistry;

PHYS 3172/3174 – Physics II with Laboratory;

Participating departments: ININ, INEL, ICOM, INME, INQU.

References

- **Class Notes** prepared by Dr. Resto.
- Hollomon Jr, James K.; Surface-Mount Technology for PC Boards; Prompt Publications; 1995.
- Lee, Ning-Cheng; Reflow Soldering Processes and Troubleshooting: SMT, BGA, CSP and Flip Chip Technologies; Newnes from Elsevier Science; 2001.
- Davidson, Homer L.; SMD Electronics Projects; Prompt Publications; 2000.
- Messina, William S.; Statistical Process Control for Surface Mount Technology; 1999.
- Prasad, Ray P.; Surface Mount Technology: Principles and Practice; Kluwer Academic Publishers; 1997.
- IPC-A-610 Task Group; Acceptability for Electronic Assemblies Rev. D; IPC Association; 2004.
- Tricker, Ray; ISO 9001-2000 for Small Businesses; Butterworth-Heinemann; 2001.

Purpose

This course is designed for specific (ChE, EE, IE, ME) engineering majors interested in Surface-Mount Technology (SMT), a critical technology to Puerto Rico's Electronics and Mechanical Cluster activities. The course promotes interdisciplinary team learning and process improvement. By the end of the course students will understand surface mount and through hole manufacturing processes.

Course Goals

- Demonstrate Surface Mount Technology processes and materials; emphasis on stencil printing, component pick and place, and soldering in a forced convection oven. Other processes that could be discussed are hand loading, wave soldering, and product testing. Provide students with hands-on experience with surface mount processes
- Define process qualification activities in response to new product introduction.
- Define DfX considerations for successful PCB manufacturing.
- Prepare students for future PCB manufacturing activities for outside customers.
- Develop problem-solving, teamwork and communications skills in students.

Requirements

All students are expected to come to class all the time (attend required lecture and laboratory sessions), on time, and prepared; do all assigned readings and related homework; actively participate in class discussions; take all tests and turn-in all assigned homework and projects and satisfy all assessment criteria to receive credit for the course.

Department and Campus Policies

Class attendance: Class attendance is compulsory. The University of Puerto Rico, Mayagüez Campus, reserves the right to deal at any time with individual cases of non-attendance. Professors are expected to record the absences of their students. Frequent absences affect the final grade, and may even result in total loss of credits. Arranging to make up work missed because of legitimate class absence is the responsibility of the student. (Bulletin of Information Undergraduate Studies).

Absence from examinations: Students are required to attend all examinations. If a student is absent from an examination for a justifiable reason acceptable to the professor, he or she will be given a special examination. Otherwise, he or she will receive a grade of zero or "F" in the examination missed. (Bulletin of Information Undergraduate Studies)

Final examinations: Final written examinations must be given in all courses unless, in the judgment of the Dean, the nature of the subject makes it impracticable. Final examinations scheduled by arrangements must be given during the examination period prescribed in the Academic Calendar, including Saturdays. (see Bulletin of Information Undergraduate Studies).

Partial withdrawals: A student may withdraw from individual courses at any time during the term, but before the deadline established in the University Academic Calendar. (see Bulletin of Information Undergraduate Studies).

Complete withdrawals: A student may completely withdraw from the University of Puerto Rico, Mayagüez Campus, at any time up to the last day of classes. (see Bulletin of Information Undergraduate Studies).

Disabilities: Reasonable accommodation will be provided according to the Americans with Disability Act (ADA) Law. Students will identify themselves with the Institution and the instructor for course and assessment (exams) accommodations. For more information please call the Office for Services to Students with Disabilities in the Dean of Students office (Chemistry Building, room 019); phones (787)265-3862 or (787)832-4040 extensions 3250 or 3258.

Ethics: Any academic fraud is subject to the disciplinary sanctions described in article 14 and 16 of the revised General Student Bylaws of the University of Puerto Rico contained in Certification 018-1997-98 of the Board of Trustees. The professor will follow the norms established in articles 1-5 of the Bylaws.

Sexual Harassment: Certification 130-2014-2015 states: Sexual harassment in the workplace and in the study environment is an illegal and discriminatory act and is against the best interests of the University of Puerto Rico. All persons who understand they have been subject to acts of sexual harassment at the University of Puerto Rico may file a complaint and request that the institution investigate, where necessary, and assume the corresponding action by the university authorities. If the complainant is a student, he or she must refer his or her complaint to the Office of the Student Ombudsperson or that of the Dean of Students.

Hostigamiento Sexual: La Certificación 130-2014-2015, indica: El hostigamiento sexual en el empleo y en el ambiente de estudio es una práctica ilegal y discriminatoria, ajena a los mejores intereses de la Universidad de Puerto Rico. Toda persona que entienda ha sido objeto de actuaciones constitutiva de hostigamiento sexual en la Universidad de Puerto Rico podrá quejarse para que se investigue, de ser necesario, y se tome la correspondiente acción por parte de las autoridades universitarias. Si quien reclama fuera estudiante, deberá referir su queja a la Oficina de la Procuradora Estudiantil o al Decanato de Estudiantes.

Certification 36 (2018-2019): Discrimination by Sex and Gender on Modality of Sexual Violence: "The University of Puerto Rico prohibits discrimination based on sex, sexual orientation, and gender identity in any of its forms, including that of sexual harassment. According to the Institutional Policy Against Sexual Harassment at the University of Puerto Rico, Certification Num. 130, 2014-2015 from the Board of Governors, any student subjected to acts constituting sexual harassment, may turn to the Office of the Student Ombudsperson, the Office of the Dean of Students, and/or the Coordinator of the Office of Compliance with Title IX for an orientation and/or formal complaint."

Certification 06-43 of the Academic Senate states, "The academic guidelines for offering online courses," defines: Traditional face-to-face courses are those that have less than 25% of the course's regular contact hours via the Internet. Therefore, a three-credit course will be considered "face to face" if, of the 45 hours of regular contact, 11 or less are taught via the Internet. According to certification 16-43 of the Academic Senate, a course may include up to 25% of its total contact hours via the Internet. The objective of this is so that all professors have this alternative in the case of any unscheduled eventuality.

Law 51: The Comprehensive Educational Services Act for People with disabilities states that after identifying with the instructor and the institution, the student with disabilities will receive reasonable accommodation in their courses and evaluations. For more information contact the Department of Counseling and Psychological services at the Office of the Dean of Students (Office DE 21) or call 787-265-3864 or 787-832-4040 x 3772, 2040 and 3864.

General Topics

#	Topic
1	Overview of the Model Factory activity: manufacturing activity, customer(s), current team members, current challenges.
2	Product and process overview: SMT component types; typical printed circuit assembly process (SMT versus TH).
3	Safety (solder paste dispensing) and electrostatic discharge (ESD) concerns; utilities required for running the process.
4	Solder paste chemistry; solder alloys; material issues; transition to lead-free paste.
5	Paste dispensing (DEK 265); solder defects and process trouble-shooting; related documentation (min. six hour experience).
6	SMT component placement (XP-143, IP-3); component reels and feeders; mistake-proofing tactics; placement defects and trouble-shooting; related documentation. Introduction to Flexa software. Pick and place program preparation; relevance of component geometry. Product changeover activities at pick and place. <i>Interaction</i> with pick & place (min. six hour experience).
7	Solder reflow (Electrovert Atmos 2000); use of nitrogen; reflow defects and trouble-shooting; related documentation. Reflow recipe preparation; temperature profiler (min. four hour experience).

8 Pre-oven and post-oven inspection: acceptability of Electronics Assemblies; IPC-610 rev. D; related documentation. Pre- and post-oven automated inspection vendor solutions.
Interaction with reflow oven, nitrogen, and inspection activities (**min. four hour experience**).

9 Capacity considerations; modeling SMT line activities.

10 Post-SMT: wave soldering; post-solder cleaning; wave solder defects and trouble-shooting.
Post-SMT: hand loading, back loading; manual to automated solutions.
Post-SMT: panel routing (ATI 204CM). Post assembly: product testing.

11 New product introduction; DFx (x=Manufacturability, Assembly and Test) considerations in printed circuit assembly.

12 Introduction to CNC machining; experience in Cincinnati Milacron Arrow 500.

Course wrap-up. Q&A.

INSTRUCTOR INFORMATION SHEET**General Information**

Instructor: Dr. Pedro Resto pedro.resto@upr.edu, (787) 464-3163
Teaching assistant: José González jose.gonzalez40@upr.edu, (787) 219-2715
Office: IE 103
Lectures: MWF 8:30-9:20 am (II-203).
Labs experience: Depends on student schedule (teams of 2-3).
Office hours: MW 9:30 am - 12:00 pm.

Evaluation / Grade Distribution

Lab experience	50%
Attendance & involvement:	30%
Exams (one or two in semester)	20%
Total	100%

Grading System

A: 90-100 %

B: 80-89 %

C: 70-79 %

D: 65-69 %

F: 64 % or below

Grades will vary slightly depending of the final grade distribution.

Instructional Strategy

Lectures will be offered by Pedro Resto, team members, or visitors; current team members will facilitate the Lab activities. Teams for labs will include three to five students (depending on class size).

Classroom Rules

Beepers & phones need to be turned off during class.

Short & tight pants not allowed.