

ME 452

Numerical Control of Manufacturing Processes

Spring 2024

MW 2:00-2:50 pm LuMEB 3100

Lab Hours: Friday 12:00-1:50 & 2:00-3:50 pm LuMEB 0023A

Instructor: Ricardo Toro

Office Hours:

LuMEB 022 – 026

MW 11:00 am -12:00 pm or by appointment (torosant@illinois.edu)

Topics to be covered:

1. General introduction to Numerically Controlled (NC) machines

Historical review of machine-tool development

Review of basic machining processes

Components of a typical NC system

Classification of NC systems

2. Programming of CNC machines (Done predominantly in Lab)

Information required in a NC program

Manual programming

Computer-assisted programming

3. Language, communication and HMI services in CNC systems

Basic idea of languages and parsing

State model for an NC machine executive

4. Real-time NC Interpolators (Linear and Circular)

Basic idea of interpolated motion

DDA based interpolator

Linear and circular interpolation

Feedrate interpolation

Software interpolators

5. Hardware in the NC Loop

Basic modeling of dynamic systems

First and second order systems
NC loop components

6. Analysis and design of the NC Loop

Modeling of NC components
Modeling and design of an NC loop
Response analysis of an NC loop

7. Errors and error sources in NC machines

Static and quasistatic sources of errors
Dynamic errors
Modeling and compensation of NC machine-tool errors

8. Trends and New Developments in NC

Reference Books

Manufacturing Automation -- Y. Altintas
Computer Control of Manufacturing Systems -- Y. Koren
Numerical Control and Comp. Aided Manuf. -- Pressman and Williams
Robotics for Engineers -- Y. Koren
Robot Manipulators: Mathematics
Programming and Control -- R. Paul

Handouts will be provided on each topic covered in the class on Canvas.

T. A. and Lab Assistant:

Shichen Li

Office Hours TBA

Testing and Grades:

Two take-home examinations -- 20% each
Lab Assignments and Homework -- 40% total
Project -- 20% total

- All lab and homework assignments should be submitted online (Canvas). No email or hard copies will be accepted.

- Any homework or lab assignment turned in after the deadline will receive a maximum of 50% credit.
- If you believe that a project, homework, exam or lab has been graded incorrectly, see the instructor within one week after the assignment has been handed back.
- The total score s corresponds to final grades as follows.

$97\% \leq s < 100\%$	A+	$93\% \leq s < 97\%$	A	$90\% \leq s < 93\%$	A-	$s < 60\%$	F
$87\% \leq s < 90\%$	B+	$83\% \leq s < 87\%$	B	$80\% \leq s < 83\%$	B-		
$77\% \leq s < 80\%$	C+	$73\% \leq s < 77\%$	C	$70\% \leq s < 73\%$	C-		
$67\% \leq s < 70\%$	D+	$63\% \leq s < 67\%$	D	$60\% \leq s < 63\%$	D-		

Announcements:

Announcements will be done through the class website on Canvas and during Lectures.

Project:

A project is required for this class. This year the entire class will do a project on Cloud Manufacturing.

1. Students will self-assemble into teams of 3 students (within your lab section so you can use some lab hours to work together, only 1 graduate student per group).
2. The team project will be done in three parts, each part culminating with a report and/or a demonstration/evaluation.

Project Part 1: What is Cloud Manufacturing? This part will require you to do a literature survey and write a report explaining to a technically literate reader what Digital Manufacturing is. Your report will cite literature on topics such as cloud manufacturing, digital manufacturing, cyber-physical manufacturing, Industry 4.0, Internet of Things (IoT), AI, etc. in explaining how these topics are related. It will identify what efforts are underway in different regions of the world in this general area. Your research will also identify underlying socio-economic and technical drivers for digital manufacturing. You should begin this section on your work as soon as possible. (2-3 pages report)

Project Part 2: Identifying Cloud Manufacturing Resources. In this part of your project, you will identify available web resources for digital manufacturing. Your project work here will take you to different vendors of digital manufacturing software tools for computer-aided design and manufacturing (CAD/CAM), for example, Autodesk's Fusion360 and Forge or OnShape's

ecosystem and several other vendors that offer such tools over the web. You will attempt to categorize these offerings. (2-3 pages report)

Project Part 3: Configuring a CNC resource for Cloud Manufacturing. In this part of your project, all groups will work in a low-code programming environment called Node-Red to build a simple digital manufacturing application. Here, you will be given remote access to a CNC machine so that you can plan jobs, generate instructions and release them for execution on the machine. Further, you will be able to monitor the machine.

Your TA will work closely with your group to help you accomplish this.

Graduate students

Graduate students must take this course for 4 credits (1 unit) and work on a supplement project. The students will self-assemble into teams of 2 students and give a 15-minute presentation about an assigned topic (contact the instructor for more details).

Course Outcome

The outcome we expect of this course:

- a. Basic understanding of devices (numerically controlled manufacturing machinery) and device architectures that form the building blocks of modern manufacturing systems.
- b. An understanding of how engineering fundamentals are applied in the working and design of such systems.
- c. A perspective on how such manufacturing machines are integrated into a manufacturing system.
- d. Hands-on experience with typical industrial automation hardware and software through laboratory assignments exercises and projects.
- e. You will become familiar with the design of computer-controlled machine tools.

Course Policy Statements

Absence Policy

It is your personal responsibility to make up materials for any missed lectures. You can use the lecture notes available on Canvas and/or ask your classmates. Specific questions can be addressed during office hours. We encourage students to not come to class, lab, or office hours when they are sick with a potentially contagious illness. Please inform your instructor/TA if you need to schedule an office hour appointment.

Academic Integrity

The work that you submit must represent your understanding of the course materials. Each student must submit their own write-up for any individual assignment (unless specified as a team activity). For team assignments, be sure to include the names of all team members that worked on the assignment.

This course has a zero-tolerance policy with regard to academic integrity violations. This includes cheating, plagiarism, fabrication, and facilitating infractions by others. You are expected to adhere to all of the rules pertaining to academic integrity outlined in the UIUC Student Code.

Academic dishonesty may result in a failing grade. Every student should pay particular attention to the Academic Integrity Policy (<https://studentcode.illinois.edu/article1/part4/1-401/>). Ignorance is not an excuse for any academic dishonesty. It is your responsibility to read this policy to avoid any misunderstanding. Do not hesitate to ask the instructor(s) if you are ever in doubt about what constitutes plagiarism, cheating, or any other breach of academic integrity. Depending on severity, recommended sanctions can range from zero on the assignment, to failure of the course, and even dismissal from the university.

Mental Health

Significant stress, mood changes, excessive worry, substance/alcohol misuse or interferences in eating or sleep can have an impact on academic performance, social development, and emotional wellbeing. The University of Illinois offers a variety of confidential services including individual and group counseling, crisis intervention, psychiatric services, and specialized screenings which are covered through the Student Health Fee. If you or someone you know experiences any of the above mental health concerns, it is strongly encouraged to contact or visit any of the University's resources provided below. Getting help is a smart and courageous thing to do for yourself and for those who care about you.

- Counseling Center (217) 333-3704
- McKinley Health Center (217) 333-2700

- National Suicide Prevention Lifeline (800) 273-8255
- Rosecrance Crisis Line (217) 359-4141 (available 24/7, 365 days a year)

If you are in immediate danger, call 911.

Community of Care

As members of the Illinois community, we each have a responsibility to express care and concern for one another. If you come across a classmate whose behavior concerns you, whether in regards to their well-being or yours, we encourage you to refer this behavior to the Student Assistance Center (217-333-0050 or <http://odos.illinois.edu/community-of-care/referral/>). Based on your report, the staff in the Student Assistance Center reaches out to students to make sure they have the support they need to be healthy and safe.

Further, as a Community of Care, we want to support you in your overall wellness. We know that students sometimes face challenges that can impact academic performance (examples include mental health concerns, food insecurity, homelessness, personal emergencies). Should you find that you are managing such a challenge and that it is interfering with your coursework, you are encouraged to contact the Student Assistance Center (SAC) in the Office of the Dean of Students for support and referrals to campus and/or community resources.

Accommodations Statement

To obtain disability-related academic adjustments and/or auxiliary aids, students with disabilities must contact the course instructor as soon as possible and provide the instructor with a Letter of Academic Accommodations from Disability Resources and Educational Services (DRES). To ensure that disability-related concerns are properly addressed from the beginning, students with disabilities who require assistance to participate in this class should apply for services with DRES and see the instructor as soon as possible. If you need accommodations for any sort of disability, please speak to me after class, or make an appointment to see me or see me during my office hours. DRES provides students with academic accommodations, access, and support services. To contact DRES, you may visit 1207 S. Oak St., Champaign, call 217-333-1970, e-mail disability@illinois.edu or visit the DRES website at <http://www.disability.illinois.edu/>. Here is the direct link to apply for services at DRES, <https://www.disability.illinois.edu/applying-services>.

Disruptive Behavior

Behavior that persistently or grossly interferes with classroom activities is considered disruptive behavior and may be subject to disciplinary action. Such behavior inhibits other students' ability to learn and an instructor's ability to teach. A student responsible for disruptive behavior may be required to leave class pending discussion and resolution of the problem and may be reported to

the Office for Student Conflict Resolution (<https://conflictresolution.illinois.edu>; conflictresolution@illinois.edu; 333-3680) for disciplinary action.

Emergency Response

Emergency response recommendations and campus building floor plans can be found at the following website: <https://police.illinois.edu/em/run-hide-fight/>. I encourage you to review this website within the first 10 days of class.

Religious Observances

Illinois law requires the University to reasonably accommodate its students' religious beliefs, observances, and practices in regard to admissions, class attendance, and the scheduling of examinations and work requirements.

Students should complete the [Request for Accommodation for Religious Observances](https://cm.maxient.com/reportingform.php?UnivofIllinois&layout_id=39) form (https://cm.maxient.com/reportingform.php?UnivofIllinois&layout_id=39) should any instructors require an absence letter in order to manage the absence. In order to best facilitate planning and communication between students and faculty, students should make requests for absence letters as early as possible in the semester in which the request applies.

Sexual Reporting Obligation

The University of Illinois is committed to combating sexual misconduct. Faculty and staff members are required to report any instances of sexual misconduct to the University's Title IX and Disability Office. In turn, an individual with the Title IX and Disability Office will provide information about rights and options, including accommodations, support services, the campus disciplinary process, and law enforcement options.

A list of the designated University employees who, as counselors, confidential advisors, and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: wecare.illinois.edu/resources/students/#confidential.

Other information about resources and reporting is available here: wecare.illinois.edu.

Family Educational Rights and Privacy Act (FERPA)

Any student who has suppressed their directory information pursuant to Family Educational Rights and Privacy Act (FERPA) should self-identify to the instructor to ensure protection of the privacy of their attendance in this course. See <https://registrar.illinois.edu/academic-records/ferpa/> for more information on FERPA.

Anti-Racism and Inclusivity Statement

The Grainger College of Engineering is committed to the creation of an anti-racist, inclusive community that welcomes diversity along a number of dimensions, including, but not limited to, race, ethnicity and national origins, gender and gender identity, sexuality, disability status, class, age, or religious beliefs. The College recognizes that we are learning together in the midst of the Black Lives Matter movement, that Black, Hispanic, and Indigenous voices and contributions have largely either been excluded from, or not recognized in, science and engineering, and that both overt racism and micro-aggressions threaten the well-being of our students and our university community.

The effectiveness of this course is dependent upon each of us to create a safe and encouraging learning environment that allows for the open exchange of ideas while also ensuring equitable opportunities and respect for all of us. Everyone is expected to help establish and maintain an environment where students, staff, and faculty can contribute without fear of personal ridicule, or intolerant or offensive language. If you witness or experience racism, discrimination, micro-aggressions, or other offensive behavior, you are encouraged to bring this to the attention of the course director if you feel comfortable. You can also report these behaviors to Campus Belonging Resources (<https://diversity.illinois.edu/diversity-campus-culture/belonging-resources/>). Based on your report, Members of the Office of the Vice Chancellor for Diversity, Equity & Inclusion staff will follow up and reach out to students to make sure they have the support they need to be healthy and safe. If the reported behavior also violates university policy, staff in the Office for Student Conflict Resolution may respond as well and will take appropriate action.