

Department of Mechanical and Aerospace Engineering
The University of Texas at Arlington
Introduction to Robotics – ME/AE 5337 Online

Instructor: Prof. P. S. Shiakolas

Office: *MS Teams* **Phone:** (817) 272-5715 **Email:** shiakolas@uta.edu

Web Page: Canvas but some resources are available at <http://mars.uta.edu/me5337>

Faculty Profile: <https://www.uta.edu/profiles/panayiotis-shiakolas>

Office Hours: *Online through MS Teams by appointment (appointment must be made through email)*

Technology Requirements: This course will be taught in an online synchronous modality. You are required to have access to the Internet and a computer with camera and microphone capabilities (especially for asking questions and for the exams).

It is your responsibility to familiarize yourselves with and learn to use Canvas for the purposes of this course; accessing posted resources, submitting assignments, participating in discussions, and taking examinations.

Prerequisites: Graduate standing or consent of instructor

Text: *Introduction to Robotics: Mechanics and Control* 3rd edition by John J. Craig

Course description: An overview of industrial robots and applications to traditional and emerging applications. Coordinate systems and homogeneous transformations, kinematics of manipulators; motion characteristics and trajectories; dynamics and control of manipulators; actuation and design issues. Programming of industrial robotic manipulators in the laboratory. Also offered as AE 5337 and credit will be given only once.

Grading Policy

Attendance (0.125 point each): Attendance will be taken at the beginning of class. If you come to class late, you will not take any attendance points once I start taking attendance. I reserve the right do not allow you in the classroom if you are habitually late as this is distracting to the rest of the class.

Homework (to be defined): Homework will be either analytical and/or computational. Treat the homework as the means of practicing and understanding the concepts presented in class; as such you are encouraged to discuss concepts and the homework with each other or obtain information from outside sources. However, all work turned in must reflect your own understanding of the material at the time of writing. Homework is due at the specified time on Canvas, Late homework will not be accepted except in extreme circumstances. It is imperative that you work all assigned homework for your own benefit since not all problems will be graded.

Projects (to be defined): Each project will be counted and added to your grade. The total for the class will be adjusted appropriately. ~~Some projects might utilize the robots and other resources in the MARS lab meaning that you will be required to learn the robot programming language (some support will be provided).~~ We might also have research projects on topics of interest or contemporary topics. Projects will require you to complete a formal project report and to defend/present in class and demonstrate your work. Same guidelines as those for the homework apply reference to turning in for grading your own work. Unlike homework, all projects will be individual unless otherwise specified. I reserved the right to ask anyone to demonstrate or discuss their project at any time. **All projects must be completed with a passing grade (> 60%) to earn a passing grade in the course.**

Mid-semester Exam (20 points): The exam will be comprehensive and may consist of two parts; an analytical and/or a computational. The exam will be closed book-notes but I may provide some formulas if needed. If there is a computational component, it will be assigned appropriately. You will a week lead time notification.

Final Exam (35 points): A comprehensive exam that may consist of two parts; an analytical and/or a computational. The exam will be closed book-notes but I may provide some formulas if needed. If there is a computational part it will be assigned appropriately.

Makeup Policy: No make-up will be given for missed work unless the student has a credible, documented excuse or an emergency, which should also be approved by the instructor (i.e., a report from doctor's office to document illness, an official document signed by the responsible university personnel for school related activities, etc.)

Grade Grievances: Once graded work is returned, you have only one week to raise objection to the earned grade otherwise the grade is permanent.

Assume no collaboration is allowed unless expressed permission is obtained from the instructor.

Anyone collaborating on any component on the course on work to be turned in for credit

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will be earning a failing grade in the course and reported to the university.

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Guaranteed Grading Scale: The guaranteed grading scale based upon the minimum percentage number of points earned is shown below. The required percentages will not be increased but they may be decreased based upon the overall class average at the end of the semester. No incomplete grades will be given for projects or the class except in extreme circumstances and if prior arrangements are made with me.

90% - 100%: A, 80% - 89%: B, 70% - 79%: C, 60% - 69%: D, 0 - 60%: F

Note: the instructor reserves the right to make changes, with notification to you, to the grading policy as needed to maintain the integrity of the assessment process while adjusting for unforeseen circumstances. In such cases, actions will be taken to ensure that such changes do not negatively impact you, the student.

Expectations for Out-of-Class Study: Beyond the time required to attend each class meeting, students enrolled in this course should expect to spend at least an additional 9 hours per week of their own time in course-related activities, including reading required materials, completing assignments, etc.

Email Communication: Email communication will be through the MyMav system to your official UTA issued email account. It is your responsibility to check your account often. Any email communication must include the following subject heading: ME 5337 – Fall 2020: brief description of topic. If email does not originate from your UTA email account and with the correct subject heading it will not be answered. I usually reply to student emails close to the end of the work day or within one business day. Note that I do not answer emails outside normal work hours, one day before work is to be turned in, and two days before an examination. You must follow proper decorum in all email communication.

Software: You may use any computer software that you like, but make sure that you are proficient in it for solving the assignments for this class. Limited software support will be provided for Mathematica (<http://www.wolfram.com>), LabVIEW (<http://www.ni.com>), MATLAB (<http://www.mathworks.com>), and SCILAB (<http://www.scilab.org>). **Robotics Toolbox** – There are two versions of this toolbox; one requires MATLAB and the other requires SCILAB. Note that SCILAB is a free software package similar to MATLAB.

Miscellaneous: If you have a disability, any religious holidays that you need to observe or anything else that might interfere with this class and you would like for me to know about it, **you** must inform me in writing no later than the second class meeting.

Testbeds: Demonstration / Experimental Setups / Robot Programming Languages
(Maybe possible for some of them due to COVID-19)

- IBM 7535 SCARA – programmed using AML Language
- Adept Robots – Viper 6-DOF articulated, Cobra 4-DOF SCARA, Python 3-DOF Cartesian
- Motor(s) controlled through LabVIEW
- Quanser 5-bar robot

Additional Reference Material

- M. W. Spong, Hutshinson and M. Vidyasagar, *Robot Dynamics and Control*
- R. P. Paul, *Robot Manipulators: Mathematics, Programming and Control*
- L. Sciavicco and B. Siciliano, *Modeling and Control of Robot Manipulators*
- K. Lynch and F. Park *Modern Control Robotics: Mechanics, Planning and Control*
- R. P. Paul, *Robot Manipulators: Mathematics, Programming and Control*
- Lung-Wen Tsai, *Robot Analysis: The Mechanics of Serial and Parallel Manipulators*
- R. M. Murray, Z. Xi, and S. S. Sastry, *A Mathematical Introduction to Robotic Manipulation*
- M. W. Spong, F.L. Lewis, and C.T. Abdallah, *Robot Control: dynamics, motion planning, and analysis*
- F.L. Lewis, C.T. Abdallah, D.M. Dawson, *Control of robot manipulators*
- Plethora of Mathematica and MATLAB books at the library and web resources.
- SCILAB reference material is available at SCILAB web page.
- **Additional material will be provided as needed (either as photocopies or as PDF).**

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GENERAL INFORMATION COMMON TO ALL COURSES

Introduction to Robotics- ME/AE 5337 Fall 2019

Department of Mechanical and Aerospace Engineering

University of Texas at Arlington

Academic Integrity: Students enrolled in this course are expected to adhere to the UT Arlington Honor Code:

I pledge, on my honor, to uphold UT Arlington's tradition of academic integrity, a tradition that values hard work and honest effort in the pursuit of academic excellence. I promise that I will submit only work that I personally create or contribute to group collaborations, and I will appropriately reference any work from other sources. I will follow the highest standards of integrity and uphold the spirit of the Honor Code.

UT Arlington faculty members may employ the Honor Code as they see fit in their courses, including (but not limited to) having students acknowledge the honor code as part of an examination or requiring students to incorporate the honor code into any work submitted. Per UT System Regents' Rule 50101, section 2.2, suspected violations of university's standards for academic integrity (including the Honor Code) will be referred to the Office of Student Conduct. Violators will be disciplined in accordance with University policy, which may result in the student's suspension or expulsion from the University. Additional information is available at <https://www.uta.edu/conduct/>.

Attendance: At The University of Texas at Arlington, taking attendance is not required but attendance is a critical indicator in student success. Each faculty member is free to develop his or her own methods of evaluating students' academic performance, which includes establishing course-specific policies on attendance.

However, while UT Arlington does not require instructors to take attendance in their courses, the U.S. Department of Education requires that the University have a mechanism in place to mark when Federal Student Aid recipients "begin attendance in a course". UT Arlington instructors will report when students begin attendance in a course as part of the final grading process. Specifically, when assigning a student a grade of F, faculty report the last date a student attended their class based on evidence such as a test, participation in a class project or presentation, or an engagement online via Blackboard. This date is reported to the Department of Education for federal financial aid recipients.

Grade Grievances: Any appeal of a grade in this course must follow the procedures and deadlines for grade-related grievances as published in the current undergraduate catalog. See <http://catalog.uta.edu/academicregulations/grades/#undergraduatetext>
See <http://www.uta.edu/deanofstudents/student-complaints/index.php>.

Institution Information: UTA students are encouraged to review the below institutional policies and informational sections and reach out to the specific office with any questions. To view this institutional information, please visit the [Institutional Information](https://resources.uta.edu/provost/course-related-info/institutional-policies.php) page (<https://resources.uta.edu/provost/course-related-info/institutional-policies.php>) which includes the following policies among others:

- Drop Policy
- Disability Accommodations
- Title IX Policy
- Academic Integrity
- Student Feedback Survey
- Final Exam Schedule

Drop Policy: Students may drop or swap (adding and dropping a class concurrently) classes through self-service in MyMav from the beginning of the registration period through the late registration period. After the late registration period, students must see their academic advisor to drop a class or withdraw. Undeclared students must see an advisor in the University Advising Center. Drops can continue through a point two-thirds of the way through the term or session. It is the student's responsibility to officially withdraw if they do not plan to attend after registering. Students will not be automatically dropped for non-attendance. Repayment of certain types of financial aid administered through the University may be required as the result of dropping classes or withdrawing. For more information, contact the Office of Financial Aid and Scholarships (<http://wweb.uta.edu/aaofa/>).

Disability Accommodations: UT Arlington is on record as being committed to both the spirit and letter of all federal equal opportunity legislation, including The Americans with Disabilities Act (ADA), The Americans with Disabilities Amendments Act (ADAAA), and Section 504 of the Rehabilitation Act. All instructors at UT Arlington are required by law to provide "reasonable accommodations" to students with disabilities, so as not to discriminate on the basis of disability. Students are responsible for providing the instructor with official notification in the form of a letter certified by the Office for Students with Disabilities (OSD). Only those students who have officially documented a need for an accommodation will have their request honored. Students experiencing a range of conditions (Physical, Learning, Chronic Health, Mental Health, and Sensory) that may cause diminished academic performance or other barriers to learning may seek services and/or accommodations by contacting:

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The Office for Students with Disabilities (OSD) www.uta.edu/disability or calling 817-272-3364. Information regarding diagnostic criteria and policies for obtaining disability-based academic accommodations can be found at www.uta.edu/disability.

Counseling and Psychological Services (CAPS) www.uta.edu/caps/ or calling 817-272-3671 is also available to all students to help increase their understanding of personal issues, address mental and behavioral health problems and make positive changes in their lives.

Non-Discrimination Policy: The University of Texas at Arlington does not discriminate on the basis of race, color, national origin, religion, age, gender, sexual orientation, disabilities, genetic information, and/or veteran status in its educational programs or activities it operates. For more information, visit <http://www.uta.edu/eos>

Title IX Policy: The University of Texas at Arlington ("University") is committed to maintaining a learning and working environment that is free from discrimination based on sex in accordance with Title IX of the Higher Education Amendments of 1972 (Title IX), which prohibits discrimination on the basis of sex in educational programs or activities; Title VII of the Civil Rights Act of 1964 (Title VII), which prohibits sex discrimination in employment; and the Campus Sexual Violence Elimination Act (SaVE Act). Sexual misconduct is a form of sex discrimination and will not be tolerated. For information regarding Title IX, visit www.uta.edu/titleIX or contact Ms. Jean Hood, Vice President and Title IX Coordinator at (817) 272-7091 or jmhood@uta.edu.

Student Feedback Survey: At the end of each term, students enrolled in classes categorized as "lecture", "seminar," or "laboratory" shall be directed to complete an online Student Feedback Survey (SFS). Instructions on how to access the SFS for this course will be sent directly to each student through MavMail approximately 10 days before the end of the term. Each student's feedback enters the SFS database anonymously and is aggregated with that of other students enrolled in the course. UT Arlington's effort to solicit, gather, tabulate, and publish student feedback is required by state law; students are strongly urged to participate. For more information, visit <http://www.uta.edu/sfs>

Final Review Week: A period of five class days prior to the first day of final examinations in the long sessions shall be designated as Final Review Week. The purpose of this week is to allow students sufficient time to prepare for final examinations. During this week, there shall be no scheduled activities such as required field trips or performances; and no instructor shall assign any themes, research problems or exercises of similar scope that have a completion date during or following this week unless specified in the class syllabus. During Final Review Week, an instructor shall not give any examinations constituting 10% or more of the final grade, except makeup tests and laboratory examinations. In addition, no instructor shall give any portion of the final examination during Final Review Week. During this week, classes are held as scheduled. In addition, instructors are not required to limit content to topics that have been previously covered; they may introduce new concepts as appropriate.

Student Success Programs: UT Arlington provides a variety of resources and programs designed to help students develop academic skills, deal with personal situations, and better understand concepts and information related to their courses.

Resources include [tutoring by appointment](#), [drop-in tutoring](#), [etutoring](#), [supplemental instruction](#), [mentoring](#) (time management, study skills, etc.), [success coaching](#), [TRIO Student Support Services](#), and [student success workshops](#). For additional information, please email resources@uta.edu, or view the [Maverick Resources](#) website.

The IDEAS Center (<https://www.uta.edu/ideas/>) (2nd Floor of Central Library) offers FREE [tutoring](#) and [mentoring](#) to all students with a focus on transfer students, sophomores, veterans and others undergoing a transition to UT Arlington. Students can drop in or check the schedule of available peer tutors at www.uta.edu/IDEAS, or call (817) 272-6593.

The English Writing Center (411LIBR): The Writing Center offers FREE tutoring in 15-, 30-, 45-, and 60-minute face-to-face and online sessions to all UTA students on any phase of their UTA coursework. Register and make appointments online at the [Writing Center](https://uta.mywconline.com) (<https://uta.mywconline.com>). Classroom visits, workshops, and specialized services for graduate students and faculty are also available. Please see [Writing Center: OWL](#) for detailed information on all our programs and services.

The Library's 2nd floor [Academic Plaza](#) (<http://library.uta.edu/academic-plaza>) offers students a central hub of support services, including IDEAS Center, University Advising Services, Transfer UTA and various college/school advising hours. Services are available during the [library's hours](#) of operation.

Electronic Communication: UT Arlington has adopted MavMail as its official means to communicate with students about important deadlines and events, as well as to transact university-related business regarding financial aid, tuition, grades, graduation, etc. All students are assigned a MavMail account and are responsible for checking the inbox regularly. There is no additional charge to students for using this account, which remains active even after graduation. Information about activating and using MavMail is available at <https://oit.uta.edu/services/email/>

Emergency Exit Procedures: Should we experience an emergency event that requires us to vacate the building, students should exit the room and move toward the nearest exit. When exiting the building during an emergency, one should never

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take an elevator but should use the stairwells. Faculty members and instructional staff will assist students in selecting the safest route for evacuation and will make arrangements to assist students with disabilities.

Library Information:

Ask for Help

- [Academic Plaza Consultation Services](http://library.uta.edu/academic-plaza) (library.uta.edu/academic-plaza)
- [Ask Us](http://ask.uta.edu/) (ask.uta.edu/)
- [Research Coaches](http://libguides.uta.edu/researchcoach) (http://libguides.uta.edu/researchcoach)

Resources

- [Library Tutorials](http://library.uta.edu/how-to) (library.uta.edu/how-to)
- [Subject and Course Research Guides](http://libguides.uta.edu) (libguides.uta.edu)
- [Librarians by Subject](http://library.uta.edu/subject-librarians) (library.uta.edu/subject-librarians)
- [A to Z List of Library Databases](http://libguides.uta.edu/az.php) (libguides.uta.edu/az.php)
- [Course Reserves](https://uta.summon.serialssolutions.com/#!/course_reserves) (https://uta.summon.serialssolutions.com/#!/course_reserves)
- [Study Room Reservations](http://openroom.uta.edu/) (openroom.uta.edu/)

Emergency Phone Numbers: In case of an on-campus emergency, call the UT Arlington Police Department at **817-272-3003** (non-campus phone), **2-3003** (campus phone).

You may also dial **911**.

Non-emergency number 817-272-3381

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KEEP FOR YOUR RECORDS

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Academic Dishonesty:

It is the philosophy of The University of Texas at Arlington that academic dishonesty is a completely unacceptable mode of conduct and will not be tolerated in any form. All persons involved in academic dishonesty will be disciplined in accordance with University regulations and procedures. Discipline may include suspensions or expulsion from the University.

“Scholastic dishonesty includes but is not limited to cheating, plagiarism, collusion, the submission for credit of any work or materials that are attributable in whole or in part to another person, taking an examination for another person, any act designed to give unfair advantage to a student or the attempt to commit such acts.” (Regents’ Rules and Regulations, Part One, Chapter VI, Section 3, Subsection 3.2, Subdivision 3.22)

Instructors may employ the Honor Code as they see fit in their courses, including (but not limited to) having students acknowledge the honor code as part of an examination or requiring students to incorporate the honor code into any work submitted. Per UT System *Regents’ Rule* 50101, §2.2, suspected violations of university’s standards for academic integrity (including the Honor Code) will be referred to the Office of Student Conduct. Violators will be disciplined in accordance with University policy, which may result in the student’s suspension or expulsion from the University.

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I promise that I will submit only work that I personally create or that I contribute to group collaborations, and I will appropriately reference any work from other sources. I will follow the highest standards of integrity and uphold the spirit of the Honor Code.

College of Engineering Ethics

You are required to visit the college of engineering Academic Honesty webpage (<http://www.uta.edu/engineering/current-students/academic-honesty.php>) and must go through the information on this page, the Resources section and the Important Related Links. study the presented information, the Resources section and the Important Related Links. After you go study the material, you must sign and return the attached sheet conforming that you studied the material on the Academic Honesty webpage, you understand the implications of the presented material and that you will abide and follow the instructions. You must return this signed sheet at the second class meeting.

Signature and Acknowledgment

By signing below, I affirmed that have been provided a syllabus and I understand the information in the syllabus as reviewed by the instructor, and I am responsible for adhering to all the policies in the syllabus. I also understand the information presented in the College of Engineering Academic Honesty web page and the consequences of not-following the honesty rules. I also understand that in order to master the material taught in this course, I must be proactive and take responsibility for my own learning, sincerely attempt the work assigned by the instructor, turn in my own work for grading purposes, complete reading assignments, actively participate in class discussion, and seek assistance as needed outside class.

Name (Block letters)

Student ID

Date:

Signature

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SIGN AND RETURN TO INSTRUCTOR ON SECOND CLASS MEETING

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Name (Block letters)

Student ID

Date:

Signature

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Introduction to Robotics – ME 5337 / AE 5337

Course Outline/Tentative Topics

Introduction	<ul style="list-style-type: none">• Definitions, Robot Manufacturers, Traditional Applications, Classifications• Robot types: Articulated, SCARA, Cartesian, Polar, etc.• Robot Programming Languages• Meso and Micro Robotics• Other Contemporary and Emerging Applications
Spatial Transformations	<ul style="list-style-type: none">• Coordinate Reference Frames• Homogeneous Transformations
Robot kinematics	<ul style="list-style-type: none">• Denavit-Hartenberg Parameters & Other Approaches• Kinematic Equations• Position and Velocity• Degrees of Freedom• Differential Relations• Inverse Kinematics• Manipulator Jacobian, Static Forces• Accuracy and Repeatability
Robot Dynamics	<ul style="list-style-type: none">• Force Acceleration Equation• Newtonian, Lagrangian, and Other approaches• State Variable Representation• Dynamic Equations Representations
Motion Trajectory & Path Planning	<ul style="list-style-type: none">• Joint Space• Cartesian Space
Manipulator Control	<ul style="list-style-type: none">• Position, Velocity• Dynamic Characteristics• Classical Control• Computed Torque – Time permitting• Digital Computed Torque – Time permitting• Other Control Techniques – Time permitting
Other topics and emerging applications	<p>These topics will be introduced from available literature and time permitting or through guest lectures.</p> <p>Surgical Robots, Mobile Robots, Biomimetic Robots, Micro/Nano Robots</p>
Experimental Testbeds	<p>These testbeds might be made available depending on interest</p> <p>Robotic testbeds in the MARS lab</p> <p>Motor(s) for setting up single or multi-joint robots to apply concepts presented in class such as kinematics, trajectory planning and controls</p>

Note: The instructor reserves the right to adjust this outline in any way that serves the educational needs of the students enrolled in this course

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RULES FOR THE MARS LAB

THINK SAFETY FIRST

**IN ADDITION TO THE SAFETY LECTURE,
THESE RULES MUST BE FOLLOWED WHILE IN THE ROBOTICS LAB**

**ONLY AUTHORIZED USERS ARE ALLOWED IN THE LAB and
POWER ON AND USE THE ROBOTIC DEVICES**

- **SOME OF THE ROBOTS DO NOT HAVE VISUALS (LIGHTS) INDICATING THAT THE ROBOT MOTOR POWER IS ON, ALWAYS BE ALERT AND STAY OUTSIDE THE ROBOT WORKSPACE IF THE POWER IS ON**
- **ONLY AUTHORIZED USERS ARE ALLOWED TO POWER ON THE ROBOTS
AUTHORIZATION CAN ONLY BE GIVEN BY Dr. SHIAKOLAS**
- **FOR SAFETY REASONS YOU MUST OPERATE THE ROBOTS AT SLOW SPEEDS AND YOU MUST ALWAYS HAVE A TEAM MEMBER PRESENT WHILE POWER IS ON**
- **ALWAYS HOLD THE TEACH PENDANT AND STAY CLOSE TO THE EMERGENCY BUTTON WHILE THE ROBOT POWER IS ON**
- **IF A ROBOT IS IN A COLLISION COURSE OR ABOUT TO DAMAGE ANY EQUIPMENT DO NOT TRY TO STOP IT BY GRASPING IT - GET OUT OF THE WAY! /**
- **USE THE EMERGENCY STOP BUTTON ON THE TEACH PENDANT**
- **IF YOU INTENTIONALLY DAMAGE ANY ROBOTS OR OTHER EQUIPMENT YOU WILL BE GIVEN A FAILING CLASS GRADE AND REPORTED TO THE UNIVERSITY ADMINISTRATION**
- **THE MARS LAB IS USED BOTH FOR RESEARCH AND TEACHING.
DO NOT DISTURB ANY EXPERIMENTAL SETUPS IN THE LAB - YOU CAN GET MORE INFORMATION ABOUT THE EXPERIMENTS/RESEARCH PERFORMED BY CONSULTING THE RESEARCHERS.
IF YOU DISTURB ANY EXPERIMENTAL TESTBEDS YOU WILL BE GIVEN A FAILING GRADE IN THE CLASS.**
- **IT IS A PRIVILEGE AND NOT A RIGHT TO USE THE MARS LAB. IF YOU DO NOT FOLLOW THE RULES, YOU WILL BE DENIED ACCESS WHICH WILL AUTOMATICALLY YIELD TO A FAILING CLASS GRADE**
- **Dr. SHIAKOLAS, THE MAE DEPARTMENT AND THE UNIVERSITY OF TEXAS AT ARLINGTON AND UT SYSTEM ARE NOT TO BE HELD LIABLE FOR ANY INJURIES DUE TO NEGLIGENCE AND/OR BY NOT FOLLOWING COMMON SENSE SAFETY RULES**

WHEN IN DOUBT ASK

I HAVE READ, UNDERSTOOD AND I WILL STRICTLY ADHERE TO THE ABOVE RULES

UTA ID#

NAME

Signature

DATE

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