

Course Outline

1. COURSE INFORMATION

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| Session Offered | Fall 2015 | |
| Course Name | Robot Mechanics & Mechatronics | |
| Course Code | MAN TECH 4RM3 | |
| Date(s) and Time(s) of lectures | Tuesday Evenings from 6:30 – 9:30 pm | |
| Program Name | Manufacturing Technology | |
| Calendar Description | Basic robot categories; robot components; mobility/constraint analysis; workspace analysis; manipulator kinematics and motion trajectories; non-redundant and redundant sensing/actuation of manipulators; manipulator statics; singularities; and manipulator dynamics. | |
| Instructor(s) | Dr. Timber Yuen | E-Mail: timber@mcmaster.ca Office: MARC 270 |

2. COURSE SPECIFICS

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| Course Description | Theories behind operation and control of various motors, actuators and sensors commonly used in automation and robotics are first introduced. Then, the use of micro controllers to integrate the various sensors and actuators is discussed. Robot types, categories and workspace analysis methods are examined to facilitate the discussion of robot cell design and cycle time analysis. Forward kinematics, inverse kinematics, and trajectory planning topics are investigated as well. The Val+ language will be used in the study of robot programming. Two hands on lab experiments will be used to improve the understanding of the material covered in the lectures. | | |
| Instruction Type | Code | Type | Hours per term |
| | C | Classroom instruction | 30 |
| | L | Laboratory, workshop or fieldwork | 6 |
| | T | Tutorial | |
| | DE | Distance education | |
| | Total Hours | | 36 |
| Resources | ISBN | Textbook Title & Edition | Author & Publisher |
| | ISBN 978-0-470-60446-5 | “Introduction to Robotics: Analysis, Control, Applications”, 2nd Edition, 2011 | Niku, Saeed B. Wiley |
| | Other Supplies | Source | |
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| Prerequisite(s) | ENGTECH 3SD3 (or MANTECH 3MD3) and MANTECH 3CT3 and registered in Manufacturing Engineering Technology | | |
| Corequisite(s) | N/A | | |
| Antirequisite(s) | MAN TECH 4MC3 | | |
| Course Specific Policies | N/A | | |
| Departmental Policies | Students must maintain a GPA of 3.5/12 to continue in the program. | | |

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| | <p>In order to achieve the required learning objectives, on average, B.Tech. students can expect to do at least 3 hours of “out-of-class” work for every scheduled hour in class. “Out-of-class” work includes reading, research, assignments and preparation for tests and examinations.</p> <p>Where group work is indicated in the course outline, such collaborative work is mandatory.</p> <p>The use of cell phones, iPods, laptops and other personal electronic devices are prohibited from the classroom during the class time, unless the instructor makes an explicit exception.</p> <p>Announcements made in class or placed on Avenue are considered to have been communicated to all students including those individuals that are not in class. Instructor has the right to submit work to software to identify plagiarism.</p> | |
| 3. SUB TOPIC(S) | | |
| Week 1 | <p>Motors for Robotics & Automation</p> <ul style="list-style-type: none"> • Motors: DC, DC Brushless, AC, Stepper & Servo • PWM for DC Motor Speed Control • H-Bridge for Direction Control • Demo: Various Motors | Sept 8, 2015 |
| Week 2 | <p>Sensors & Grippers for Robotics</p> <ul style="list-style-type: none"> • Use of potentiometer for position feedback • Encoders • Parallel Grippers • Vacuum Grippers • Demo: Potentiometer for LED Blink Control | Sept 15, 2015 |
| Week 3 | <p>Introduction to Micro Controller</p> <ul style="list-style-type: none"> • I/O Definition • Variables • Programming a Micro Controller • Sample Programs • Truth Table Logics (for H Bridge Logics) • Demo: Stepper Motor with micro Controller | Sept 22, 2015 |
| Week 4 | <p>Lab Week 1</p> <ul style="list-style-type: none"> • Lab 1: Micro Controller Programming • Interface Sensors & Motors (DC & Stepper Motor) to the Texas Instrument MSP430 Microcontroller | Sept 29, 2015 |
| Week 5 | Mid Term Test #1 | Oct 6, 2015 |
| <i>Mid-term recess (Monday, October 12 to Saturday, October 17)</i> | | |
| Week 7 | <p>Introduction to Robotics</p> <ul style="list-style-type: none"> • Robot categories • Workspace Analysis • Accuracy & Repeatability • Forward & Inverse Kinematics (2 Link Robots) • Demo: 2 Link Robot & Delta Robot | Oct 20, 2015 |
| Week 8 | <p>Advanced Kinematics</p> <ul style="list-style-type: none"> • Mobile Frames & Fixed Frames • Joint Space, World Space & Tool Space • Coordinate Frames, Translations & Rotations • Homogeneous Transformation • Inverse Transformations • Excel Sheets for Transformations • Singularities | Oct 27, 2015 |

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| | <ul style="list-style-type: none"> Demo: 2 Link Robot under Motion Control | |
| Week 9 | Lab Week #2 <ul style="list-style-type: none"> Lab 2: Robot Kinematics Hobby Servo Motor Position Control Forward Kinematics Inverse Kinematics Motor Angle vs Joint Angle and World Position Coordinating Motors to Move in a Straight Line | Nov 3, 2015 |
| Week 10 | Mid Term Test #2 | Nov 10, 2015 |
| Week 11 | Differential Motions and Velocities, Motion Trajectory <ul style="list-style-type: none"> Joint Space vs Cartesian Space Trajectories Multiple Joints Coordinated Motion Displacement & Velocity Analysis Jacobian Matrix Robot Programming VAL+ Language for STAUBLI Robots MOVE, MOVES, APPRO, APPROX, DEPART, DEPARTS, OPENI, CLOSEI, DELAY, BREAK, TYPE commands | Nov 17, 2015 |
| Week 12 | Robot Cell Design <ul style="list-style-type: none"> Picking the right robot Work Space Analysis Robots vs Hard Automation Redundant Sensing of Manipulators Cycle Time Analysis Demo: Robot Cell Videos | Nov 24, 2015 |
| Week 13 | Final Review and Take up Problem Set #3 | Dec 1, 2015 |
| Classes end – Tuesday December 8, 2015 Final examination period: Wednesday December 9, 2015 to Tuesday, December 22, 2015 All examinations MUST BE written during the scheduled examination period. | | |
| Note that this structure represents a plan and is subject to adjustment term by term. The instructor and the University reserve the right to modify elements of the course during the term. The University may change the dates and deadlines for any or all courses in extreme circumstances. If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. | | |
| 4. ASSESSMENT OF LEARNING *including dates* | | Weight |
| Assignments | | 9 % |
| Mid Term Test #1 | | 25 % |
| Mid Term Test #2 | | 25 % |
| Lab Participation & Reports | | 4 % |
| Final Exam | | 37 % |
| TOTAL | | 100 % |
| Percentage grades will be converted to letter grades and grade points per the University calendar. | | |
| 5. LEARNING OUTCOMES | | |
| 1. Recommend the type of sensors and motors used for the design of a robotics system. | | |
| 2. Programming of a micro controller to integrate inputs (sensors and push buttons) and outputs (signal lights and motors) | | |
| 3. Identify the type of robot used in a manufacturing system. | | |
| 4. Recommend the type of robot used in a manufacturing cell based on the requirements on accuracy, work envelope and the manufacturing process. | | |
| 5. Design the trajectory (path & velocity) of a robot based on motion specifications. | | |

6. Perform cycle time analysis and design a robot work cell based on specifications.

6. POLICIES

Anti-Discrimination

The Faculty of Engineering is concerned with ensuring an environment that is free of all discrimination. If there is a problem, individuals are reminded that they should contact the Department Chair, the Sexual Harassment Officer or the Human Rights Consultant, as soon as possible.

<http://www.mcmaster.ca/policy/General/HR/Anti-Discrimination%20policy.pdf>

Academic Integrity

You are required to exhibit honestly and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various kinds of academic dishonesty please refer to the Academic Integrity Policy, located at: <http://www.mcmaster.ca/policy/Students-AcademicStudies/AcademicIntegrity.pdf>.

The following illustrates only three forms of academic dishonesty:

1. Plagiarism. E.g. the submission of work that is not own or for which other credit has been obtained
2. Improper collaboration in group work
3. Copying or using unauthorized aids in tests and examinations.

Requests for Relief for Missed Academic Term Work (Assignments, Mid-Terms, etc.)

The McMaster Student Absence Form is a self-reporting tool for **Undergraduate Students** to report absences that last up to 3 days and provides the ability to request accommodation for any missed academic work. Please note, this tool cannot be used during any final examination period.

You may submit a maximum of 1 Academic Work Missed requests per term. It is YOUR responsibility to follow up with your Instructor immediately regarding the nature of the accommodation.

If you are absent more than 3 days or exceed 1 request per term you MUST visit your Associate Dean's Office (Faculty Office). You may be required to provide supporting documentation.

This form should be filled out immediately when you are about to return to class after your absence. <http://www.mcmaster.ca/msaf/>

E-Learning Policy

Consistent with the Bachelor of Technology's policy to utilize e-learning as a complement to traditional classroom instruction, students are expected to obtain appropriate passwords and accounts to access Avenue To Learn for this course. Materials will be posted by class for student download. It is expected that students will avail themselves of these materials prior to class. Students should be aware that, when they access the electronic components of this course, private information such as first and last names, user names for the McMaster e-mail account, and program affiliation may become apparent to all other students in the course. The available information is dependent on the technology used. Continuation in this course will be deemed consent to this disclosure. If you have any questions or concerns about this disclosure please discuss this with the course instructor. Avenue can be accessed via

<http://avenue.mcmaster.ca>.

Communications

It is the student's responsibility to:

- Maintain current contact information with the University, including address, phone numbers, and emergency contact information.
- Use the University provided e-mail address or maintain a valid forwarding e-mail address.
- Regularly check the official University communications channels. Official University

communications are considered received if sent by postal mail, by fax, or by e-mail to the student's designated primary e-mail account via their @mcmaster.ca alias.

- Accept that forwarded e-mails may be lost and that e-mail is considered received if sent via the student's @mcmaster.ca alias.
- Check the McMaster/Avenue email and course websites on a regular basis during the term.

Turnitin (Optional)

This course will be using a web-based service (Turnitin.com) to reveal plagiarism. Students submit their assignment/work electronically to Turnitin.com where it is checked against the internet, published works and Turnitin's database for similar or identical work. If Turnitin finds similar or identical work that has not been properly cited, a report is sent to the instructor showing the student's work and the original source. The instructor reviews what Turnitin has found and then determines if he/she thinks there is a problem with the work. Students who do not wish to submit their work to Turnitin.com must still submit a copy to the instructor. No penalty will be assigned to a student who does not submit work to Turnitin.com. All submitted work is subject to normal verification that standards of academic integrity have been upheld (e.g., on-line search, etc.). To see the Turnitin.com Policy, please go to

<http://www.mcmaster.ca/academicintegrity/turnitin/students/>

Protection of Privacy Act (FIPPA)

The Freedom of Information and Protection of Privacy Act (FIPPA) applies to universities. Instructors should take care to protect student names, student numbers, grades and all other personal information at all times. For example, the submission and return of assignments and posting of grades must be done in a manner that ensures confidentiality.

<http://www.mcmaster.ca/univsec/fippa/fippa.cfm>

Academic Accommodation of Students with Disabilities Policy

Students who require academic accommodation must contact Student Accessibility Services (SAS) to make arrangements with a Program Coordinator. Academic accommodations must be arranged for each term of study. Student Accessibility Services can be contacted by phone 905-525-9140 ext. 28652 or e-mail sas@mcmaster.ca. For further information consult McMaster's policy for Academic Accommodation of Students with Disabilities

<http://www.mcmaster.ca/policy/Students-AcademicStudies/AcademicAccommodation-StudentsWithDisabilities.pdf>

Students must forward a copy of the SAS accommodation to the instructor of each course and to the Program Administrator of the B.Tech. Program immediately upon receipt. If a student with a disability chooses NOT to take advantage of a SAS accommodation and chooses to sit for a regular exam, a petition for relief may not be filed after the examination is complete. <http://sas.mcmaster.ca>

Student Code of Conduct

The Student Code of Conduct (SCC) exists to promote the safety and security of all the students in the McMaster community and to encourage respect for others, their property and the laws of the land. McMaster University is a community which values mutual respect for the rights, responsibilities, dignity and well-being of others. The purpose of the Student Code of Conduct is to outline accepted standards of behavior that are harmonious with the goals and the well-being of the University community, and to define the procedures to be followed when students fail to meet the accepted standards of behavior. All students have the responsibility to familiarize themselves with the University regulations and the conduct expected of them while studying at McMaster University.

<http://judicialaffairs.mcmaster.ca/pdf/SCC.pdf>