Multidisciplinary Senior Design
Project Readiness Package

Project Title:	Development of a Tribometer for Soft Contacts
Project Number: (assigned by MSD)	P##xxx (P/ending year/project #, e.g. P15001 finishes in 2015 and is project number 001)
Primary Customer: (provide name, phone number, and email)	Rui Liu, 585-475-6819, rleme@rit.edu
Sponsor(s): (provide name, phone number, email, and amount of support)	Rui Liu, 585-475-6819, rleme@rit.edu
Preferred Start Term:	fall 2020
Faculty Champion: (provide name and email)	Dr. Rui Liu, rleme@rit.edu Dr. Patricia Iglesias pxieme@rit.edu
Other Support:	N/A
Project Guide: (assigned by MSD)	

Prepared By Bob Yang, Dr Rui Liu　　　　Date June 10th 2020

Received By　　　　Date

Items marked with a * are required, and items marked with a † are preferred if available, but we can work with the proposer on these.

Project Information

*Overview:

In studies of friction, to be able to estimate and quantify friction forces and coefficient of friction as well as the relationship between friction and other factors, special laboratory instruments called tribometers are developed. Tribometers are testing apparatus designed to be used in study of friction between same or different materials. Some basic functions of tribometers include measurement of friction forces, application of normal load/forces and creating relative motion between specimens studied. Numerous designs of tribometers have been developed to suit each unique friction scenario. In this project, this research application the system to be developed for is soft materials. Friction between soft materials and rigid materials such as metal are not as simple as described in general theory of friction. Soft materials can deform easily and surface interactions involve many additional factors such as adhesive properties and fluid. The specific material chosen for the friction research application is PDMS, a type of transparent silicon like soft material with a level of adhesive properties on its surface. Primitive research has shown tribological properties of this material differs from general theories of friction while more research is needed to discover further details.

For this project the objective is to design, construct and test an tribometer for data collection and optical observation during friction testing between soft material and metallic surface. The tribometer system should be designed to conduct both pin-on disk and thrust-washer tests between soft materials and rigid metal surfaces. The sample materials for this project will be PDMS and stainless steel. The system created in this project must be able to collect force/torque data of friction while the soft material and metallic surface are static and in relative motion for static and kinetic friction cases. Optical observation of the contacting surface during testing should also be one of its essential functions. The mechanical system including major structural component and specimen mounting must be structurally sufficient and rigid at where desired. Electrical and control systems should be designed for precise control of motion, ease of operation and good reliability. Upon delivery of the project, a comprehensive manual that covers the design, specification and operation instruction of the tribometer system must also be drafted and delivered.

* Preliminary Customer Requirements (CR):

What attributes does the customer seek in the final project? Each CR should map to one or more ER (see below).

Mechanical Requirements:

1. Test specimens can be mounted firmly and relative motion can be driven while specimen surfaces stay in contact.
2. Test specimens shall be constrained in its vertical position during test runs. While fixed, slight up or down motion and displacement of the PDMS or metal specimen shall not be permitted.

3. The contact surfaces of PDMS specimen and metal specimen must be in as ideal to parallel as can be possibly made.
4. The structure and mounting of a fixed system shall be rigid and structurally sound.
5. The types of contact between materials shall be pin-on-disk and thrust-washer.

Electrical Requirements

6. Kinetic friction motion must be precisely regulated in terms of speed.
7. The system shall compose of an electrical sub system that incorporates power supply, motion actuation, motion and motor control, data collection and other necessary parts. All components shall be integrated into the electrical sub system in an organized manner providing ease of operation and reliability.

Data Collection and observation Requirements

8. Friction data can be monitored and collected with a sensor system suited for the range. Preliminary experiments may be conducted to determine a reason range for sensor selection after conceptual design stage.
9. The contacting surface should be clearly monitored while the machine is in test operation. Phonoma occurring at the contacting surface shall be observed with clearity. example: optically observable or filmed with a camera.

† **Functional Decomposition** (will not be given to the students, but will be provided to the team's guide for reference):
What functionality will be delivered in order to satisfy the customer requirements? This may be in the form of a list of functions, a function tree or a FAST diagram.

10. Display friction data value and collect friction data with respect to time for designated testing period.
11. Optically observe and record interactions at contacting surfaces during testing.
12. Adjustments of mechanical alignments, parallelism and specimen positions.
13. Mounting and dismounting specimens.
14. Driving of relative motion between specimens with precise speed control.
15. Constrain of specimen movement during testing.

* **Preliminary Engineering Requirements (ER)**:
Mechanical Requirements:

1. Test specimens can be mounted firmly and relative motion can be driven while specimen surfaces stay in contact.

Metrics: Visual inspection of relative motion.
Specifications: If specimens break loose from stand, then it needs to be fixed.

2. Test specimens shall be constrained in its vertical position during test runs. While fixed, slight up or down motion and displacement of the PDMS or metal specimen shall not be permitted.

Metrics: specimen vertical displacement, specimen holder motion. needs to be fixed
Specifications: 0.01mm

3. The contact surfaces of PDMS specimen and metal specimen must be in as ideal to parallel as can be possibly made.

Metrics: parallelism. off angles or vertical difference per length.
Specifications:

4. The structure and mounting of a fixed system shall be rigid and structurally sound.

Metrics: structure deflection, access play, deflection
Specifications: 0.01mm

5. The types of contact between materials shall be pin-on-disk and thrust-washer.

Metrics: equipment for the Two types of contact must be designed
Specifications:

Electrical Requirements

6. Kinetic friction motion must be precisely regulated in terms of speed.

Metrics: rotation per minute at different settings among a selected range.
Specifications: 1 rpm +-

7. The system shall compose of an electrical sub system that incorporates power supply, motion actuation, motion and motor control, data collection and other necessary parts. All components shall be integrated into the electrical sub system in an organized manner providing ease of operation and reliability.

Metrics: Does not apply
Specifications:

Data Collection and observation Requirements

8. Friction data can be monitored and collected with a sensor system suited for the range. Preliminary experiments may be conducted to determine a reason range for sensor selection after conceptual design stage.

Metrics: force in newtons and torque in newton meters
Specifications: To be determined

9. The contacting surface should be clearly monitored while the machine is in test operation. Phonoma occurring at the contacting surface shall be observed with clearity. example: optically observable or filmed with a camera.

Metrics: visual inspection, resolution
Specifications: to be determined.

[*] **Constraints:**

Budget:

Main Module Mass: The main module shall be designed to a reasonable weight for ease of operation and reposition.

[†] **Potential Concepts:** (will not be given to the students, but will be provided to the team's guide for reference):refer to "Friction Science and Technology" by Peter J B

[*] **Project Deliverables:**
Minimum requirements:

- All design documents (e.g., concepts, analysis, detailed drawings/schematics, BOM, test results)
    - System Manual
    - Bill of Materials
- working prototype
- technical paper
- poster
- All teams finishing during the spring term are expected to participate in ImagineRIT

Additional required deliverables:

- List here, if applicable

[†] **Budget Information:**

Building Materials:
    Mechanical: steel, metal, foundation plate, bearings 800$
    Electrical: wires 100$
Equipment and sensor devices:
    stepper motors, force sensor systems, micro processors, etc 1200$

Experimental Material:
PDMS : 50
total: 2150$

[*] Intellectual Property:

Describe any IP concerns or limitations. According to RIT policy, students have the right to retain any IP they generate during a course, but some students voluntarily agree to be placed on projects where they will be asked to assign their IP. If a sponsor wishes to have a team assign their IP, we need to know ahead of time so that we can place appropriate students on the team.

In order to ensure that students can discuss their projects openly during presentations and job interviews, we ask that no more than ~20% of the project be considered confidential.

Project Resources

† Required Resources (besides student staffing):
Describe the resources necessary for successful project completion. When the resource is secured, the responsible person should initial and date to acknowledge that they have agreed to provide this support. We assume that all teams with ME/ISE students will have access to the ME Machine Shop and all teams with EE students will have access to the EE Senior Design Lab, so it is not necessary to list these. Limit this list to specialized expertise, space, equipment, and materials.

Faculty list individuals and their area of expertise (people who can provide specialized knowledge unique to your project, e.g., faculty you will need to consult for more than a basic technical question during office hours)	**Initial/ date**
Dr Rui Liu, Dr.Patricia Iglesias	
Environment (e.g., a specific lab with specialized equipment/facilities, space for very large or oily/greasy projects, space for projects that generate airborne debris or hazardous gases, specific electrical requirements such as 3-phase power)	**Initial/ date**
Equipment (specific computing, test, measurement, or construction equipment that the team will need to borrow, e.g., CMM, SEM,)	**Initial/ date**
Materials (materials that will be consumed during the course of the project, e.g., test samples from customer, specialized raw material for construction, chemicals that must be purchased and stored)	**Initial/ date**
Other	**Initial/ date**

† Anticipated Staffing By Discipline:
Indicate the requested staffing for each discipline, along with a brief explanation of the associated activities. "Other" includes students from any department on campus besides those explicitly listed. For example, we have done projects with students from Industrial Design, Business, Software Engineering, Civil Engineering Technology, and Information Technology. **If you have recruited students to work on this project (including student-initiated projects), include their names here.**

Dept.	# Req.	Expected Activities
BME		
CE		
EE	2	electrical system design, stepper motor and actuator control, hardware programing, construction of circuits
ISE		
ME	3	mechanical design, machining, assembly, system integration, friction testing
Other		

* **Skills Checklist:**
Indicate the sills or knowledge that will be needed by students working on this project. Please use the following scale of importance:
1 = must have
2 = helpful, but not essential
3 = either a very small part of the project, or relates to a "bonus" feature
blank = not applicable to this project

Biomedical Engineering

	BME Core Knowledge		BME Elective Knowledge
	Matlab		Medical image processing
	Aseptic lab techniques		COMSOL software modeling
	Gel electrophoresis		Medical visualization software
	Linear signal analysis and processing		Biomaterial testing/evaluation
	Fluid mechanics		Tissue culture
	Biomaterials		Advanced microscopy
	Labview		Microfluidic device fabrication and measurement
	Simulation (Simulink)		Other (specify)
	System physiology		
	Biosystems process analysis (mass, energy balance)		
	Cell culture		
	Computer-based data acquisition		

	Probability & statistics		
	Numerical & statistical analysis		
	Biomechanics		
	Design of biomedical devices		

Computer Engineering

	CE Core Knowledge		CE Elective Knowledge
	Digital design (including HDL and FPGA)		Networking & network protocols
	Software for microcontrollers (including Linux and Windows)		Wireless networks
	Device programming (Assembly, C)		Robotics (guidance, navigation, vision, machine learning, control)
	Programming: Python, Java, C++		Concurrent and embedded software
	Basic analog design		Embedded and real-time systems
	Scientific computing (including C and Matlab)		Digital image processing
	Signal processing		Computer vision
	Interfacing transducers and actuators to microcontrollers		Network security
			Other (specify)

Electrical Engineering

	EE Core Knowledge		EE Elective Knowledge
1	Circuit Design (AC/DC converters, regulators, amplifies, analog filter design, FPGA logic design, sensor bias/support circuitry)	2	Digital filter design and implementation
1	Power systems: selection, analysis, power budget	2	Digital signal processing
	System analysis: frequency analysis (Fourier, Laplace), stability, PID controllers, modulation schemes, VCO's & mixers, ADC selection		Microcontroller selection/application
1	Circuit build, test, debug (scope, DMM, function generator	3	Wireless: communication protocol, component selection
	Board layout		Antenna selection (simple design)
	Matlab		Communication system front end design
	PSpice		Algorithm design/simulation
1	Programming: C, Assembly		Embedded software design/implementation

	Electromagnetics: shielding, interference		Other (specify)

Industrial & Systems Engineering

	ISE Core Knowledge		**ISE Elective Knowledge**
	Statistical analysis of data: regression	1	Design of Experiment
1	Materials science		Systems design – product/process design
1	Materials processing, machining lab		Data analysis, data mining
	Facilities planning: layout, mat'l handling	1	Manufacturing engineering
	Production systems design: cycle time, throughput, assembly line design, manufacturing process design		DFx: manufacturing, assembly, environment, sustainability
	Ergonomics: interface of people and equipment (procedures, training, maintenance)		Rapid prototyping
	Math modeling: OR (linear programming, simulation)		Safety engineering
1	Project management		Other (specify)
	Engineering economy: Return on Investment		
	Quality tools: SPC		
1	Production control: scheduling		
	Shop floor IE: methods, time studies		
1	Computer tools: Excel, Access, AutoCAD		
1	Programming (C++)		

Mechanical Engineering

	ME Core Knowledge		**ME Elective Knowledge**
1	3D CAD		Finite element analysis
	Matlab programming		Heat transfer
1	Basic machining		Modeling of electromechanical & fluid systems
1	2D stress analysis		Fatigue and static failure criteria
	2D static/dynamic analysis		Machine elements
	Thermodynamics		Aerodynamics
	Fluid dynamics (CV)		Computational fluid dynamics
	LabView		Biomaterials

	Statistics		Vibrations
1	Materials selection		IC Engines
			GD&T
			Linear Controls
			Composites
			Robotics
		1	advanced machining