Rutgers University
Department of Mechanical & Aerospace Engineering
2023-2024 Senior Design Projects
14:650:487/488 Aerospace Engineering Design I/II

Aerospace Engineering Projects

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AE PROJECT 1

Mechanical Bird

Advisor: Prof. Prosenjit Bagchi

Email: pbagchi@soe.rutgers.edu

Project Goals: Design and fabrication of a device that can fly like a bird

Project Envisioned Outcomes: Generation of aerodynamic thrust and lift using flapping wings.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design		☑			
Analysis		☑			
Hand tools		☑			
Traditional Machining		☑			
CNC machining	☑				
3D printing		☑			
Welding		☑			
Wiring		☑			
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)		☑			
Microcontrollers (e.g., Arduino)		☑			
Bonding	☑				
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab			☑		
Comsol			☑		
Python	☑				
Ansys	☑				
SolidWorks			☑		
Other CAD packages	☑				
Siemens NX	☑				
LabView	☑				
E-Calc	☑				
AVL	☑				
Xfoil	☑				
Machine vision program	☑				

AE PROJECT 2

UAV-Based Aerosol Sampling and Analysis System

Advisor: Prof. Xiaoli Bai

Email: xiaoli.bai@rutgers.edu

Project Goals:

1. Design and develop a lightweight, efficient, and cost-effective UAV platform suitable for aerosol sampling in various atmospheric conditions.

2. Integrate aerosol sampling instruments and sensors that can accurately collect and measure aerosol properties, such as particle size, concentration, and chemical composition.

3. Implement an autonomous flight control system that optimizes flight paths based on real-time aerosol data, environmental conditions, and mission objectives, maximizing the efficiency of the sampling process.

4. Design a user-friendly ground control interface that allows operators to easily plan, monitor, and manage the UAV missions and access the collected aerosol data.

5. Validate the performance and accuracy of the UAV-based aerosol sampling system through a series of field tests and comparisons with other established measurement methods.

Project Envisioned Outcomes:

A functional, reliable, and efficient UAV system designed explicitly for aerosol sampling, capable of operating in various atmospheric conditions and covering large areas time-efficiently.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design				☑	
Analysis				☑	
Hand tools		☑			
Traditional Machining		☑			
CNC machining		☑			
3D printing			☑		
Welding		☑			
Wiring			☑		
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)		☑			
Microcontrollers (e.g., Arduino)				☑	
Bonding	☑				
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab				☑	
Comsol		☑			
Python				☑	
Ansys		☑			
SolidWorks		☑			
Other CAD packages		☑			
Siemens NX		☑			
LabView		☑			
E-Calc			☑		
AVL		☑			
Xfoil		☑			
Machine vision program			☑		

AE PROJECT 3

Airplane Stability and Control Derivatives

Advisor: Prof. Haim Baruh

Email: baruh@soe.rutgers.edu

Project Goals: To build an aircraft whose stability and control derivatives are within desired ranges

Project Envisioned Outcomes: Construction of a plane

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design				☑	
Analysis			☑		
Hand tools				☑	
Traditional Machining			☑		
CNC machining			☑		
3D printing	☑				
Welding			☑		
Wiring				☑	
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)				☑	
Microcontrollers (e.g., Arduino)			☑		
Bonding			☑		
Processing (e.g., vacuum bag, autoclave)			☑		

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab				☑	
Comsol			☑		
Python			☑		
Ansys			☑		
SolidWorks			☑		
Other CAD packages			☑		
Siemens NX		☑			
LabView			☑		
E-Calc		☑			
AVL		☑			
Xfoil		☑			
Machine vision program		☑			

AE PROJECT 4

Mechanism to Deploy People and Materials from the Lunar Surface into a Lava Tube

Advisor: Prof. Haym Benaroya

Email: benaroya@soe.rutgers.edu

Project Goals: Design and manufacture small-scale prototype.

Project Envisioned Outcomes: A viable concept will be designed and manufactured, showing the concept in action, and suggesting improvements.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design			☑		
Analysis			☑		
Hand tools		☑			
Traditional Machining		☑			
CNC machining		☑			
3D printing		☑			
Welding					
Wiring		☑			
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)		☑			
Microcontrollers (e.g., Arduino)		☑			
Bonding					
Processing (e.g., vacuum bag, autoclave)					

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab			☑		
Comsol			☑		
Python					
Ansys		☑			
SolidWorks			☑		
Other CAD packages					
Siemens NX					
LabView					
E-Calc					
AVL					
Xfoil					
Machine vision program					

Additional Requirements and Information:

https://www-sciencedirect-com.proxy.libraries.rutgers.edu/science/article/pii/S0094576522006853

AE PROJECT 5

Zero-Gravity Flight Experiment to Explore the Propellant

Advisor: Prof. Laurent Burlion

Email: laurent.burlion@rutgers.edu

Project Goals: Combine existing tabletop testbench with 0-g flight requirements to develop a control algorithm for propellant sloshing. The 0-g testbench will house all components pertinent to the space mission's experiment with a focus on being able to attain visual and pressure sensor data in a tightly controlled 0-g environment.

The main experiment consists of a tank containing either water or a silica based oil which will house the fluid that disrupts a satellites movement due to sloshing. Said tank is a major focus of the experiment as it will be designed to not leak over the course of a 1 year mission or when subject to repeated excitations of rotations and vibrations. This tank is to be transparent for the purpose of collecting visual data and must allow for the passing of wires to collect crucial pressure sensor data.

Project Envisioned Outcomes:

1- Test Controller software, Pressure sensor software, OBC, Control algorithms, Tank, and Camera to verify components for nano-satellite engineering model.
2- Students will design, fabricate and test a testbench that is capable of handling accelerations in the Up, Down, Forward, Aft, and Lateral directions for both fully secured configuration and a "one bolt out" configuration.
3- Students will write a checklist including all tools, ground support assembly instructions, procedures proposed for parabolic maneuvers (including just prior to and after parabolas), and identify the requested flight profile (including set up time, number and type of parabolas, in sequence) needed to complete the research.
4- Students will perform an electrical analysis for any part of the experiment that utilizes electrical power. The analysis shall compose of a Schematic, Load Table and Emergency Shutdown Procedures.
5- Students will perform a hazard source analysis to address any situations and/or equipment that may cause danger. This analysis will contain two reports: Hazard Source Checklist and Task Analysis and Risk Index Worksheet.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design			☑		
Analysis				☑	
Hand tools				☑	
Traditional Machining			☑		
CNC machining		☑			
3D printing				☑	
Welding	☑				
Wiring			☑		
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)			☑		
Microcontrollers (e.g., Arduino)			☑		
Bonding	☑				
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab				☑	
Comsol			☑		
Python			☑		
Ansys			☑		
SolidWorks				☑	
Other CAD packages			☑		
Siemens NX		☑			
LabView	☑				
E-Calc	☑				
AVL	☑				
Xfoil	☑				
Machine vision program			☑		

AE PROJECT 6

Exoskeleton Flying Suit

Advisor: Prof. Laurent Burlion

Email: laurent.burlion@rutgers.edu

Project Goals: Design an innovative exoskeleton flying vehicle to transport a person. Flight test a small-scale prototype (in a secure indoor environment) that can carry at least 5 kg.

Project Envisioned Outcomes:

1. Extensive study of the existing flying suits
2. Design of an innovative solution based on the tilt rotor mechanism previously used in Burlion Lab.
3. Study and maximize the main parameters (travel distance / flight time / ratio "mass of the person / mass of the flying suit",
4. Implementation of some advanced control algorithms Students will perform a hazard source analysis to address any situations and/or equipment that may cause danger. This analysis will contain two reports: Hazard Source Checklist and Task Analysis and Risk Index Worksheet.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design				☑	
Analysis			☑		
Hand tools			☑		
Traditional Machining			☑		
CNC machining		☑			
3D printing				☑	
Welding	☑				
Wiring			☑		
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)			☑		
Microcontrollers (e.g., Arduino)				☑	
Bonding	☑				
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab				☑	
Comsol	☑				
Python				☑	
Ansys	☑				
SolidWorks				☑	
Other CAD packages			☑		
Siemens NX	☑				
LabView	☑				
E-Calc			☑		
AVL	☑				
Xfoil		☑			
Machine vision program	☑				

Additional Requirements and Information:

Knowledge of Ardupilot or PX4

AE PROJECT 7

Design and Testing of a Novel Propulsion System for RPL

Advisor: Prof. Edward DeMauro

Email: ed451@soe.rutgers.edu

Project Goals: This project will involve the design and construction of testing equipment to aid in the analysis of a new liquid propellent system for the RPL rocket. The team will be required to conduct extensive engineering analysis to ensure safety protocols and will have regular meetings with REHS to ensure that all designs are satisfactory.

Project Envisioned Outcomes:

- Construct a new static thrust mount capable of withstanding the anticipated mechanical and thermal loads

- Design engineering controls to ensure safe operation

- Perform a 'dry run' to satisfactorily demonstrate that all systems operate safely and as expected

- Quantify thrust generated from small liquid propellent system

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design			☑		
Analysis			☑		
Hand tools		☑			
Traditional Machining		☑			
CNC machining		☑			
3D printing	☑				
Welding	☑				
Wiring		☑			
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)		☑			
Microcontrollers (e.g., Arduino)		☑			
Bonding	☑				
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab			☑		
Comsol	☑				
Python	☑				
Ansys		☑			
SolidWorks			☑		
Other CAD packages			☑		
Siemens NX			☑		
LabView		☑			
E-Calc	☑				
AVL	☑				
Xfoil	☑				
Machine vision program	☑				

AE PROJECT 8

Improvements to the Longitudinal Stability of the RPL Rocket

Advisor: Prof. Edward DeMauro

Email: ed451@soe.rutgers.edu

Project Goals: This project is focused on the use of computational and experimental methods to design and test a new tail fin for the RPL rocket. The rocket is required to maintain static stability across a wide range of Mach numbers, from low-speed out to supersonic. As a result, the design of fins to maintain control authority across this range is no trivial issue.

Project Envisioned Outcomes:

- Computationally predict the aerodynamic loading on a wing planform design to be used for RPL fin

- Experimentally verify the predictions of the computations and possibly revise simulations

- Design and construct the fins and mounting

- Demonstrate performance through onboard measurements and flight testing

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design				☑	
Analysis			☑		
Hand tools				☑	
Traditional Machining			☑		
CNC machining			☑		
3D printing		☑			
Welding	☑				
Wiring			☑		
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)			☑		
Microcontrollers (e.g., Arduino)			☑		
Bonding	☑				
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab			☑		
Comsol		☑			
Python	☑				
Ansys			☑		
SolidWorks				☑	
Other CAD packages				☑	
Siemens NX				☑	
LabView		☑			
E-Calc	☑				
AVL	☑				
Xfoil	☑				
Machine vision program	☑				

AE PROJECT 9

Active Flow Control of an RC Airplane Using Synthetic Jet Actuators

Advisor: Prof. Edward DeMauro

Email: ed451@soe.rutgers.edu

Project Goals: Fully implement and demonstrate synthetic jets are capable of improving aerodynamic loading in flight conditions while obtaining data to prove this

Project Envisioned Outcomes:

- Flight test
- Improvement of synthetic jet output
- Diagnostics to demonstrate capability

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design			☑		
Analysis			☑		
Hand tools			☑		
Traditional Machining		☑			
CNC machining		☑			
3D printing	☑				
Welding	☑				
Wiring			☑		
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)			☑		
Microcontrollers (e.g., Arduino)		☑			
Bonding	☑				
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab			☑		
Comsol	☑				
Python	☑				
Ansys		☑			
SolidWorks			☑		
Other CAD packages			☑		
Siemens NX			☑		
LabView			☑		
E-Calc	☑				
AVL	☑				
Xfoil	☑				
Machine vision program	☑				

AE PROJECT 10

Persistent Drone Weather Monitoring

Advisor: Prof. F. Javier Diez

Email: diez@soe.rutgers.edu

Project Abstract: Persistent drone weather monitoring

Project Goals: Develop a drone that can flight tethered continuously for 24hrs for weather monitoring

Project Envisioned Outcomes: Demo a drone that can achieve the project goals.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design				☑	
Analysis		☑			
Hand tools			☑		
Traditional Machining		☑			
CNC machining		☑			
3D printing		☑			
Welding		☑			
Wiring			☑		
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)				☑	
Microcontrollers (e.g., Arduino)				☑	
Bonding		☑			
Processing (e.g., vacuum bag, autoclave)		☑			

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab				☑	
Comsol		☑			
Python				☑	
Ansys		☑			
SolidWorks			☑		
Other CAD packages			☑		
Siemens NX		☑			
LabView			☑		
E-Calc			☑		
AVL		☑			
Xfoil			☑		
Machine vision program			☑		

AE PROJECT 11

Design of Lighter-Than-Air Surveillance Vehicle

Advisor: Prof. Doyle Knight

Email: ddknight@rutgers.edu

Project Goals: Design, fabricate and test lighter-than-air surveillance vehicle

Project Envisioned Outcomes: Design, fabricate and test lighter-than-air surveillance vehicle

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design	☑				
Analysis			☑		
Hand tools	☑				
Traditional Machining	☑				
CNC machining	☑				
3D printing	☑				
Welding	☑				
Wiring			☑		
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)			☑		
Microcontrollers (e.g., Arduino)			☑		
Bonding	☑				
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab			☑		
Comsol			☑		
Python		☑			
Ansys			☑		
SolidWorks			☑		
Other CAD packages	☑				
Siemens NX	☑				
LabView		☑			
E-Calc	☑				
AVL	☑				
Xfoil	☑				
Machine vision program	☑				

AE PROJECT 12

Record-Setting Water Rocket

Advisor: Prof. Jerry Shan

Email: jshan@soe.rutgers.edu

Project Goals: Develop a water rocket driven by pressurized air. It can be single or multistage, and use custom pressure vessels, or unreinforced soda bottles.

Project Envisioned Outcomes: Set a world record for altitude attained by a water rocket in one of the classes sanctioned by http://wra2.org/WRA2_Standings.php . Suggested classes include Class B Multiple State Altitude record, or Class E Open Design Unreinforced Bottle Altitude Record.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design				☑	
Analysis				☑	
Hand tools				☑	
Traditional Machining			☑		
CNC machining			☑		
3D printing				☑	
Welding	☑				
Wiring				☑	
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)				☑	
Microcontrollers (e.g., Arduino)				☑	
Bonding				☑	
Processing (e.g., vacuum bag, autoclave)				☑	

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab				☑	
Comsol				☑	
Python					
Ansys				☑	
SolidWorks					
Other CAD packages					
Siemens NX					
LabView			☑		
E-Calc					
AVL					
Xfoil					
Machine vision program					

Additional Requirements and Information:

http://wra2.org/WRA2_Standings.php

AE PROJECT 13

High Strength, Light Weight Spherical Pressure Vessel with Fiber-Reinforced Composites

Advisor: Prof. George Weng

Email: gjweng@rutgers.edu

Project Abstract: Use carbon fibers and epoxy resin to make polymer composites, and use the composites to build a spherical pressure vessel.

Project Goals: To build a light-weight composite spherical pressure vessel that can sustain high pressure without failure.

Project Envisioned Outcomes: A hardware composite spherical pressure vessel.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design		☑			
Analysis		☑			
Hand tools		☑			
Traditional Machining		☑			
CNC machining		☑			
3D printing		☑			
Welding		☑			
Wiring		☑			
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)		☑			
Microcontrollers (e.g., Arduino)		☑			
Bonding			☑		
Processing (e.g., vacuum bag, autoclave)			☑		

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab			☑		
Comsol	☑				
Python	☑				
Ansys	☑				
SolidWorks	☑				
Other CAD packages	☑				
Siemens NX	☑				
LabView	☑				
E-Calc	☑				
AVL	☑				
Xfoil	☑				
Machine vision program	☑				

AE PROJECT 14

Cooperation of A Fleet of Intelligent Mobile Plants for Unknown Territory Exploration

Advisor: Prof. Qingze Zou

Email: qzzou@rutgers.edu

Project Abstract: In this project, we seek to create and optimize a suite of strategies (algorithms) to allow a fleet of mobile plants combining both ground robots and drones to cooperate with each other efficiently and robustly, to seek resources and maximize the plants survivability in an unknown and potentially hazardous territory. The idea is to equip the plants with mobility, environment sensing (e.g., light, temperature, and vision) and communication capability (wireless communication), and allow and help the plants to communicate and share information with each other about the environment, to seek resources (e.g., water, light) and/or avoid dangers (e.g., harsh temperature and/or harmful insects), thereby, turning the group of plants into a group of social "animal-like" subjects. This project is built upon the successful outcomes of senior projects in the last a few years. The task of your team is to develop and test optimal path planning and guidance algorithms along with necessary hardware enhancement (e.g., real-time image-based navigation, guidance and control) drawing from machine learning, computer vision, and multi-agent network systems, aiming to optimally maximize the survivability of the plants in harsh environment.

Project Goals: Creating a fleet of mobile plants combining both ground robots and drones working cooperatively together to seek resources and maximize the plants survivability in an unknown and potentially hazardous territory.

Project Envisioned Outcomes: Enhance the function and capability of the robot network, develop autonomously-flying drones, and make the robots and drones working together in real-time for territory exploration.

Students Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Design		☑			
Analysis	☑				
Hand tools		☑			
Traditional Machining	☑				
CNC machining	☑				
3D printing	☑				
Welding	☑				
Wiring			☑		
Simple analog or digital electronics (e.g., resistors, capacitors, op-amps)			☑		
Microcontrollers (e.g., Arduino)			☑		
Bonding		☑			
Processing (e.g., vacuum bag, autoclave)	☑				

Software Expertise:

	None	Beginner	Intermediate	Serious Hobbyist	Professional
Matlab			☑		
Comsol	☑				
Python	☑				
Ansys	☑				
SolidWorks	☑				
Other CAD packages	☑				
Siemens NX	☑				
LabView	☑				
E-Calc	☑				
AVL	☑				
Xfoil	☑				
Machine vision program			☑		

Additional Requirements and Information:

Programming experience with Arduino and Raspberry Pi