The Shoulders of Giants Mentorship

Kepler Program Overview and Guidelines

Contents

1) Program Educational Objectives

Students who complete the Kepler Program are expected to attain the following Program Educational Objectives within the first few years of completion, depending on their grade level upon entering the program:

- Admission to, and success in, a competitive Baccalaureate program in Science, Engineering, or a related technical field.

or

- Pursuit of further mastery of Science and Engineering disciplines through the TSoG Newton Program.

2) Program Overview

2.1) Program Classes

The High School Mentorship Program is divided into two distinct class levels – Kepler and Newton. Upon adequate completion of the Kepler program, students may enroll in the Newton program for advanced material building upon the Kepler class learning objectives and engage in project based learning.

Kepler Class – 9-12th Grade Students

Johannes Kepler (1571-1630) revolutionized our understanding of the universe by introducing the first accurate model of the motion of the planets – now known as Kepler's Laws of Planetary Motion – based on the mathematics available to him in his time.

The Kepler Class will cover five disciplines of science and engineering, comprising of ten units (8 sessions each) and will approach this content through algebra, geometry, trigonometry, and some calculus. Kepler class students will meet for two unique 90 minute instructor-led sessions per week.

2.2) Program Units

The Kepler Program is divided into 10 units, which cover a variety of foundational skills in science and engineering designed to help prepare students for success in independent projects and university studies. Two units will be interleaved in each 2 month period of study, such that there are a total of at least 8 unique instructor-led sessions per unit prior to testing for that unit.

Each unit is independent of the remaining units, such that a student may join the Kepler Program at any time without falling behind.

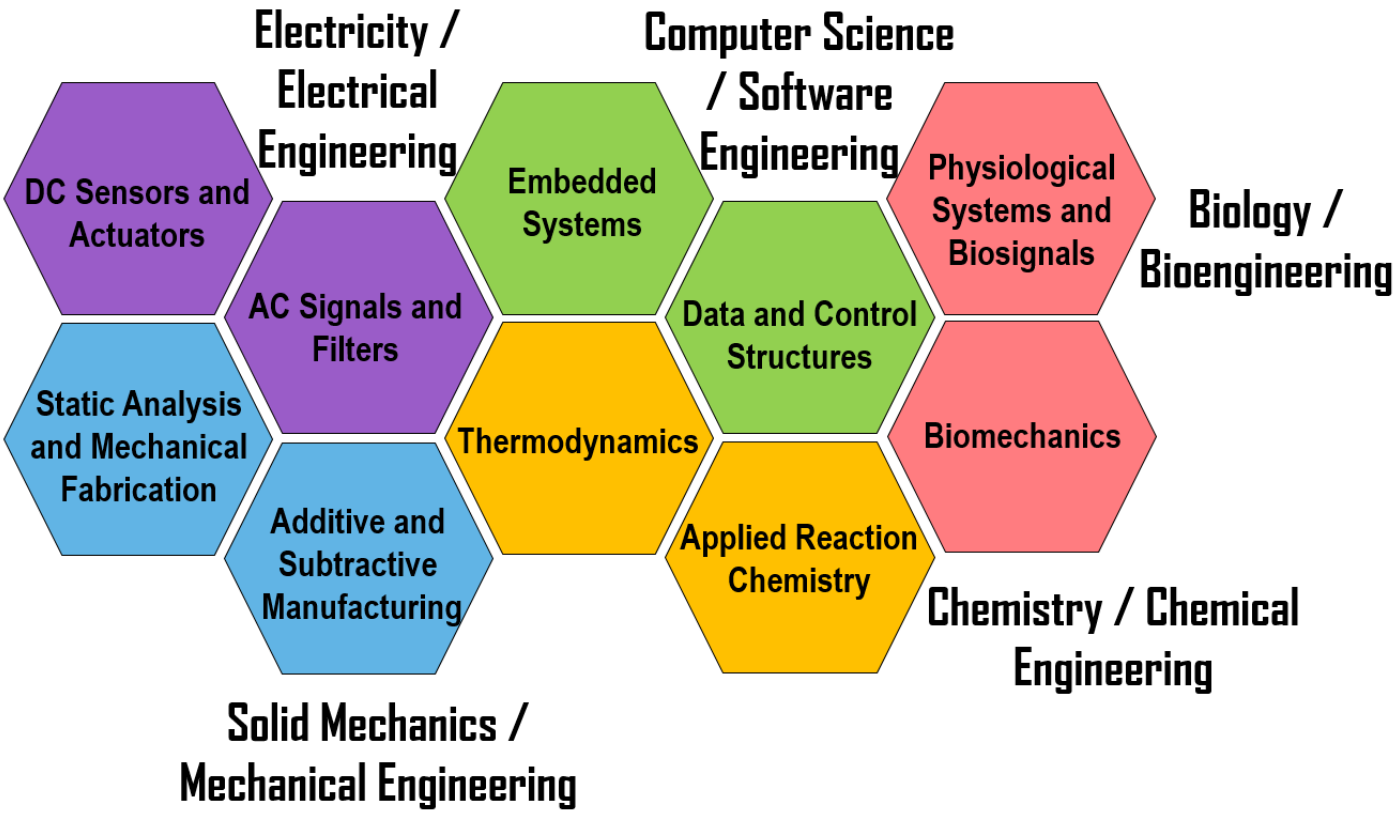

Figure 1. *A visual representation of the 10 units comprising the High School Novice Program*

The 10 units of the novice program (represented visually in Figure 1) are summarized as follows:

0101 - DC Sensors and Actuators
Covers sensors which produce changes in steady-state voltage, current, or resistance in response to physical phenomena; methods of conditioning and scaling these responses using voltage regulators, resistor networks, and operational amplifiers; and methods of driving simple DC indicators and actuators based on these conditioned responses.

0102 - AC Signals and Filters
Covers both time and frequency-domain AC signals; first and second order passive and active filters; and rectification of these signals to produce a DC output.

0103 - Embedded Systems
Includes an introduction to microcontroller programming in C; how to utilize both digital and analog outputs of a microcontroller to drive indicators and actuators; and how to utilize both digital and analog inputs of a microcontroller to respond to user interaction and physical phenomena.

0104 - Data and Control Structures
An introduction to core concepts of computer science and software engineering through the Python programming language. Covers data types and structures; conditional statements and control structures; and analysis and application of fundamental algorithms.

0105 - Physiological Systems and Biosignals
Covers both theoretical and experimental analysis of physiological systems; methods of recording, analyzing, and observing the signals associated with biological systems; a detailed look at the human cardiovascular system and the biosignals associated with it; and statistical analysis of real-world experimental data.

0106 - Static Analysis and Mechanical Fabrication
Covers reading and synthesizing mechanical engineering drawings; how to properly measure mechanical systems and determine tolerances in mechanical assemblies; how to perform static analyses to determine stress and strain acting on simple mechanical systems; and how to utilize a number of practical machine shop tools to produce physical objects from engineering drawings.

0107 - Additive and Subtractive Manufacturing
An introduction to computer aided design tools; how to utilize 3D printers for both prototyping and functional components; and methods of evaluating mechanical components for printability. Also covers subtractive manufacturing tools such as CNC mills and laser cutters to create mechanical components and systems; machining practices and standards; and digital production of mechanical drawings.

0108 - Thermodynamics
An introduction to the fundamentals of heat transfer and the ideal gas law; analysis and applications of the Carnot cycle and heat engines; and the statistical analysis of complex physical systems.

0109 – Organic Chemistry
Covers laboratory safety and techniques; the application of stoichiometry and periodic trends to understand and predict chemical interactions; and how to interpret experimental data and evaluate experimental hypotheses.

0110 – Biomechanics
An introduction to biomechanics and its relationship to physiology and anatomy; analysis of forces and moments and their effects on biomechanical models; application of kinematic conventions and measurement techniques to the study of biological systems.

2.3) Class Structure

Each instructor-led session follows the approximate structure below:

Kepler Class

0:00-0:10	Review of Previous Materials (*Instruction*)
0:10-0:25	Warm Up – Previous Materials Exercises (*Hands-on*)
0:25-0:35	New Materials (*Instruction*)
0:35-0:50	New Materials Exercises (*Hands-on*)
0:50-0:55	Review of Student Work and Feedback (*Instruction*)
0:55-1:05	Continued Exercises (*Hands-on*)
1:05-1:20	Additional Mathematical Theory and Exercises (*Mixed Instruction and Hands-on*)
1:20-1:30	Review and Adjourn (*Instruction*)

Each student enrolled will have access to all class notes, presentations, materials, and practice problems that will be uploaded to elearning.tsogiants.org. If a student misses a class, they may review these instructor materials to stay current.

3) Student Outcomes

Student Outcomes (SOs) represent the knowledge and skills expected of Kepler Program Graduates. Student outcomes are designed to prepare graduates to attain the Program Educational Objectives.

Student Outcomes for the Kepler Program are as follows:

Technical Outcomes:

a) Knowledge of the major fields of science and engineering.
b) Understanding of the basic underlying principles of a variety of technical fields.
c) An ability to apply mathematical and scientific principles to solve engineering problems.
d) An ability to use modern scientific and engineering tools.
e) An ability to analyze and interpret data and evaluate hypotheses using statistical analysis.
f) An ability to analyze and evaluate systems, components, or processes.

Non-technical Outcomes:

g) An ability to communicate effectively to a technical audience.
h) An ability to work with others on a team to develop engineering solutions or engage in scientific inquiry.
i) An ability to engage in the independent pursuit of knowledge, and a recognition of the need for ongoing continuing education.
j) Understanding of ethical and professional responsibility.

4) Unit Learning Objectives

Each unit contains 4-5 Unit Learning Objectives (ULOs) which describe, in detail, the concepts which the unit will cover. Each of these ULOs will map to one and only one SO; each unit should contain ULOs which map to both Technical (a-f) and Non-technical (g-i) SOs. Unit Learning Objectives are approved by the Industry Advisory Board.

5) Testing

5.1) General Testing

General Testing is held following completion of the 8 weeks of unit material. The time allotted for each Unit's Testing is 3 hours. Students may participate in Testing by invitation only; students are not considered for invitation unless they have attended at least 5 instructor-led sessions for the Unit.

General Testing requirements are uniquely determined for each Unit and approved by the Industry Advisory Board. To meet Testing requirements, students must demonstrate competence in each of the Unit Learning Objectives

At least three experts in the field of the Unit, as determined by the Industry Advisory Board, must be present to serve as Judges for each General Testing.

5.2) Badge Testing

All students who enter the Kepler program are issued a White name badge. Students who have satisfied attendance requirements for at least 8 of the Program Units and have been successfully tested in all of them are given the opportunity to test for a Yellow name badge and begin participation in the Newton program.

6) Program Accountability and Assessment

6.1) Student Performance Assessment

Student performance in Unit Learning Objectives will be evaluated at the end of each testing cycle. Students who attended at least 6 instructor-led sessions in a given unit will be divided into four categories:

To Be Evaluated
Students who are invited to test but are unable to attend testing for any reason will be included in this category. Students in this category may either test for this unit at a later date at a General Testing for the Unit, or as part of a Badge Testing, if eligible.

Below Expectations
Students who are either determined to be not ready to participate in testing despite attending sufficient instructor-led sessions or who fail to satisfy at least 60% of Testing requirements will be included in this category. Students in this category may either test for this unit at a later date at a General Testing for the Unit, or as part of a Badge Testing, if eligible.

Meets Expectations
Students who satisfy at least 60%, but less than 80% of Testing requirements will be included in this category.

Exceeds Expectations
Students who satisfy 80% or more of Testing requirements will be included in this category.

Units which have more than 20% of students in the Fails to Meet Expectations or Exceeds Expectations categories should be brought to the attention of the Industry Advisory Board for evaluation and potential revision of either ULOs or Testing requirements.

6.2) Unit Revision Logs

At the end of each unit, the Unit Revision Log for that unit will be updated by a TSoG Program Instructor for presentation to the Industry Advisory Board. For each time the Unit is held, this Unit Revision Log must contain:

- The dates during which the unit was most recently held.
- Changes made to the Unit since the last time it was held.
- The most recent description of the Unit included in the Unit Syllabus.
- The ULOs used during the current Testing cycle.
- The results of the Student Performance Assessment (percentage of students in each category).
- Instructor notes on recommended changes to the Unit which should be made based on recent experience Student Performance Assessment.

No instructor should ever delete information from the Unit Revision Log under any circumstances.

6.3) Program Assessment

Once per calendar year, the Industry Advisory Board must perform a Program Assessment. Student performance in all of the Units will be considered, as will the appropriateness of ULO to SO mapping. Only during this assessment may Program SOs be modified or Units be added or removed from the program.

7) Industry Advisory Board

The Industry Advisory Board (IAB) consists of industry experts and academicians with expertise in technical fields. The IAB may consist of no fewer than 4 and no more than 12 members. TSoG Directors and Staff may not serve on the IAB.

The Industry Advisory Board will meet every two months to approve Unit Learning Objectives and Testing requirements, to select Testing Judges, and to evaluate Unit Revision Logs. Once per year, the IAB will meet to perform a full Program Assessment.