**Course Overview**

In MESA (Mathematics, Engineering, Science Achievement) students apply principles of science and math, and the engineering design process in developing projects related to various disciplines in engineering. Engineering disciplines include, but are not limited to, civil engineering, mechanical engineering, biomedical engineering, packaging engineering, aeronautical/aerospace engineering, and electrical engineering. In this year-long college-preparatory course, students also explore robotics, computer programming and coding, Working in teams students complete a series of design challenges (hands-on projects) culminating with competition-ready devices such as: prosthetic arm, balsawood bridge, working model of the heart, egg drop package, propeller airplane, mousetrap-powered car. These projects promote critical thinking, communication, collaboration, creativity and provide a foundation for data collection, analysis, reflection, presentations and technical writing skills. By successfully completing the course students will be prepared to succeed in college level science and engineering. Each unit also introduces students to the real-world application of the skills and principles and highlights how they relate to possible careers in STEM fields. All units utilize the engineering design process and require students to keep an “Engineering Design Notebook” to document their thoughts processes and test data as well provide insight into the design, test and redesign process. Engineering is problem-solving and combines math, science, language arts, social studies, team building and creativity with a practical twist. In MESA students use hands-on activities and project-based learning to retain more math and science concepts. Utilizing the engineering design process to guide students through MESA’s various project based learning modules provides students with insight into engineering as well as the skills to systematically approach real-world problems. Using the 4 steps of the engineering design process: investigate, plan, create and evaluate, students will repeat the steps until they have a project worthy of entry into the MESA competition arena. Beginning with an activity to “set the stage” for the construction of a mousetrap car, students begin to acquire the vocabulary and engage in dialogue with other students..

**Unit One**: The Engineering Design Process/Kinematics – Mousetrap Car Power Challenge

In this introductory unit students will explore the question “how do things move and what is motion. Selected readings and guided research will help students to develop kinematic concepts of motion and apply this knowledge to the design challenge. In the unit, students will also be introduced to the engineering design cycle that will be used for the remainder of the year as a tool to solve multiple engineering design problems. The design challenge in unit one is to build a car propelled by the energy released in the snap of a mousetrap to power the car up a ramp with a 30 degree incline. Through this investigation students apply their understanding of kinematics to analyze motion by making measurements and calculations as well as exploring the need for transportation. Throughout the engineering design cycle students are required to document their findings in an engineering notebook in preparation for panel discussions and peer dialogue about their project.

**Unit Two**: Utilization of Engineering Design Process to integrate technical or quantitative information expressed in words in a text with a version of that information expressed visually in a model, diagram, flow chart and graph. Utilizing factual materials provided in the online MESA curriculum and research conducted through selected websites, students will develop scientific and technical terms to express the inter-relationships of the various components of the human heart. Students are also required to present their findings in a white paper and be prepared to entertain questions before a peer panel. The culmination of this unit is an articulated model of the human heart that must contain specified components and demonstrate the blood flow through the four chambers of the heart. Throughout the project students will utilize the engineering design cycle and document their findings in their engineering design notebooks.

**Unit Three**: Scientific principles to explore include Newton’s First and Second Laws, free fall and acceleration of gravity, momentum and impulse connection and typical value of drag co-efficiency. In preparation for this project, students will be required to research Newton’s laws and be prepared to defend their project design to their peers by citing specific examples of the laws. The design challenge in unit three relates to packaging engineering, culminating with the design and construction of an eggdrop container of a specified size that will achieve the highest possible ration of surviving eggs to total eggs used. As in the previous projects, drawings and research findings documented in the engineering notebook help students to convey their thoughts into words. In this unit, the engineering design notebook also helps students prepare a lab report that must include internal and external drawings of their initial designs, testing data, redesign with drawings and calculations of the surface area and volume of the container.

**Unit Four**: This unit reinforces the engineering design process through the principles of flight and aircraft design applied to the construction of a balsawood propeller airplane. Objectives of this unit include: analysis of design and construction in relation to the flight mission; application of principles of the engineering design cycle to aircraft design and construction; problem solving related to flight, lift and drag; problem solving related to balance and torque. Students will be required to compute the volume and surface area of two or three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes and right prisms. In addition students will plan an investigation to provide evidence that the change in an object’s motion depends on the sum of the forces on the object and the mass of the object. Students will also construct and interpret scatter plots for bivariant measurement data to investigate patterns of association between the quantities. Students will share their findings with their peers via power point presentations.

**Unit Five**: Prior to the start of this project, students will be required to research prosthetic devices through selected readings and recommended online websites. Where available, students will visit a Veterans’ Administration hospital as part of their research. Combining biomedical engineering, biotechnology and kinematics, this unit culminates with the design and construction of a working prosthetic arm. Utilizing principles of electrical and mechanical engineering, students incorporate circuitry and “micro processing technology to activate the fingers of the hand to grasp and relocate various specified objects. To design and construct the arm and hand students will conduct online research to investigate the following: types of motion, magnitude of motion, direction of motion, location of motion – kinematics. Included in the development of the project are scaled plans and renderings. This unit also includes the development of a technical paper, an academic display and an oral presentation, mimicking the process utilized by teams of engineers in the workplace. The paper must contain examples of math and science concepts used in the design of the arm. The academic display must provide isometric and orthographic drawings of the device. The oral presentation outlines the design process and various testing and thought processes that lead to the final design.

**Unit Six**: Proficiency in higher level mathematics will serve students well in their pursuit of a STEM career. This unit focuses on student preparation and competency in higher level mathematics courses and builds on the skills gained in previous units. Using content measured by the math sections of the PSAT and SAT, students will be provided with opportunities to hone their skills in this area through classroom instruction, peer tutoring, and practical application in the various units outlined above. The culmination of this unit provides an opportunity for students to self-assess their math skills by participating in an exam that simulates the math section of the redesigned SAT and measures competency in: mastery of linear equations and systems; problem solving and data analysis; manipulation of complex equations; and geometric and trigonometric skills most relevant to college and career readiness. Students who can: make sense of problems and persevere in solving them; reason abstractly and quantitatively; construct viable arguments and critique the reasoning of others; model with mathematics; use appropriate tools strategically; attend to precision; look for and make use of structure; look for and express regularity in repeated reasoning are students who can master higher level mathematics courses on the way to a STEM major.

**Unit Seven**: Speaking and listening are critical to student success at any and all levels. In this unit students will draw upon the skills developed in prior units and apply these skills in the preparation of an oral presentation related to any of the PBL modules outlined above or to a topic selected from a pre-determined list. College career and readiness standards outlined in the Common Core Standards require students to read closely to determine what the text says and make logical inferences from the information as well as cite specific textual evidence when writing or speaking to support conclusions. Other skills to be fine-tuned in this unit include utilization of appropriate eye contact, adequate volume and clear pronunciation to convey meaning. Providing students with speaking opportunities throughout the course to allow them to develop their presentation skills as they relate their design process and test findings, will help them build confidence and begin to build the skills necessary to communicate effectively.