Overview

Robotics and autonomous systems are emerging as one of the most important technologies of our time, and there needs to be a corresponding educational opportunity for undergraduate students at the University of Maryland. Robotics is an inherently multidisciplinary field with core components in Mechanical Engineering, Aerospace Engineering, Computer Science, and Electrical Engineering. Many engineering students want to become literate in robotics engineering fields, even if they major in another field. The field of robotics has experienced exponential growth in recent years. According to the International Federation of Robotics, 387,000 new industrial robots were installed in 2017, up significantly from around 294,000 in the previous year, creating additional high-paying jobs, especially in engineering. By 2020, there will be more than 3 million industrial robots in use, further automating our economy. Autonomous cars, trucks, and drones are bound to transform the transportation and logistics economy and home robotic systems will create limitless potential for innovations, driving up the demand for highly educated engineering students with core competency in robotics. As the flagship of the State of Maryland’s higher education, it is imperative for the UMD-College Park to lead the way in this important field and create novel curriculums and opportunities for its undergraduate students.

The A. James Clark School of Engineering currently offers a Master’s of Engineering Robotics program for graduate students through the Office of Advanced Engineering Education and the Maryland Robotics Center (MRC). This program is growing exponentially—up to 188 students in just the past few years. An undergraduate minor in Robotics and Autonomous Systems is a natural next step, and the Maryland Robotics Center is well equipped to take a leadership role in its development and administration.

Engineering and Computer Science majors currently have few options to study robotics at the undergraduate level with waitlists for robotics courses often equal to the number of students accepted in the course. The purpose of the Robotics and Autonomous Systems (RAS) minor is to allow selected Engineering and Computer Science majors access to core courses in robot design, robot programming, and control, and to provide a foundation for advanced-level courses. This degree option responds to a need initially recognized by the students themselves. The goal is to start the RAS minor in Fall 2020, administered by MRC.

Mission and Purpose

How does the program support the mission & strategic goals of UMD? The most recent UMD strategic plan (Transforming Maryland – Higher Expectations) emphasizes the university’s commitment to attracting academically talented future leaders, improving graduation of students in STEM fields, and offering financial and community support for a diverse student body. The RAS minor offers potential to affect achievement of these goals in the following ways.

● The Robotics and Autonomous System minor offers an attractive degree option to our most
**academically talented students.** This degree option will develop practical skills relevant to robotics; provide knowledge of advanced robotics concepts; improve training for jobs in robotics; increase applications for graduate study in robotics programs; and support academic relationships with robotics faculty. There are over forty faculty in the Maryland Robotics Center.

- **STEM majors are typically less diverse than students from other parts of campus.** For example, IRPA data for FY19 show that relative to campus as a whole (where women earned 46.7% of undergraduate degrees granted), graduates in Computer, Mathematical and Natural Science (37.34% female) and engineering (20.62% female) were overwhelmingly male. Relative to campus (where graduates were 12.17% African American and 10.26% Hispanics: US), undergraduates in CMNS (8.12% African American, 7% Hispanic: US) and engineering (8.03% African American, 7.55% Hispanic: US) also included fewer underrepresented minorities. Admission to RAS, which will be a limited enrollment program, will seek to correct this imbalance by taking a holistic approach to the application review process as described below.

- **The RAS minor leverages UMD’s geographic location.** The University of Maryland is located in a strategically vital part of the country with convenient access to the nation’s capital and numerous government sponsors of academic and industrial research. Students interested in either research or corporate jobs after graduation will find ample opportunities in the areas of robotics and autonomy.

What related programs are currently offered in the state of Maryland? The following table describes the programmatic offerings of other higher educational institutions in Maryland in areas related to robotics. Note from the table that the RAS minor is unique and not offered elsewhere by a public college or university in Maryland.

<table>
<thead>
<tr>
<th>Institutions</th>
<th>Related major degrees</th>
<th>Minor degrees</th>
<th>Certificate programs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Johns Hopkins University</td>
<td>None</td>
<td>Robotics</td>
<td>None</td>
</tr>
<tr>
<td>Bowie State University</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Capitol Technology University</td>
<td>Mechatronics Engineering Unmanned, Autonomous Systems</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Towson University</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>University of Maryland, Baltimore County</td>
<td>None</td>
<td>None</td>
<td>Mechatronics</td>
</tr>
<tr>
<td>University of Maryland Global Campus</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>Cecil College</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>College of Southern Maryland</td>
<td>None</td>
<td>None</td>
<td>Robotics Technology</td>
</tr>
<tr>
<td>Loyola University of Maryland</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
</tbody>
</table>
What evidence is there that the state needs or market demands graduates? The University’s ongoing membership in the Advanced Robotics Manufacturing (ARM) Institute provides a large list of potential employers in this field. Indeed, the ARM Workforce and Education Development initiative seeks to develop a national asset map to address existing training and apprenticeship programs in robotics, and the current gaps in those programs. The University of Maryland College Park should play a central role in the University System of Maryland and in the State of Maryland as a whole in providing a degree training program for undergraduate students in robotics and autonomy.

On May 4, 2018, the Maryland State Department of Education issued a request for proposals to increase the number of robotics programs in the state of Maryland or to support the already existing programs. This program was created by House Bill 115 (2016), Education-Robotics Grant Program-Establishment and shows the State’s commitment to help local school systems better prepare all students for the workforce needs of the 21st century. Copy of this call for proposals are attached in an appendix.

What data show student interest in the program? A student interest survey has been recently sent to engineering and computer science undergraduates. Students were asked whether they would be interested in pursuing the minor and if so, what type of coursework they would be interested in as minor requirements. As of November 12, 2019, 97 students have responded to the survey sent to the Clark School of Engineering. Twenty four out of 28 freshmen responded that they would pursue a RAS minor if offered, 4 were not sure. Twenty five declared that they would sign a petition to the administrators advocating for the creation of a robotics minor. Three students said maybe. Out of 32 responding sophomore, 25 would pursue RAS and 7 were not sure. Twenty nine would sign a petition, 2 maybe, and 1 would not. We are awaiting responses from CS undergraduate students. The survey results as of November 12, 2019 are attached as an appendix.

The idea of creating a robotics minor was originated by a group of engineering undergraduate students (Bryce Peterson, Graham Buck, Elise Green, Andrew Dallas, and William Zhang), who recognized themselves the need for the robotics minor. They conducted a survey among the engineering students to determine the level of interest (50 students responded affirmatively) and wrote a robotics minor proposal in the spring 2015 semester. The original student proposal is attached in an appendix. The current MRC robotics minor proposal is the continuation and amplification of this effort.

The data below indicate undergraduate student interest in robotics in the Clark School and potential interest in a robotics and autonomous systems minor.

Data from Fall 2019 Undergraduate Applications to the Clark School: Based on the information provided by the UMD Office of Undergraduate Recruitment and Scholarship Programs, the Clark School of Engineering received 1,566 applications of students already admitted to UMD and eligible for admission to the Clark School for the Fall 2019 semester. Out of the 1,566 applicants, 1,014 listed their STEM activities in their application. Out of the 1,014, 213 (21%) listed involvement in robotics clubs, teams, and competitions.

Data from the Science, Technology and Society, College Park Scholars Program: Each semester, the Science, Technology and Society, College Park Scholars Program offers a robotics service-learning practicum CPSS240 where students explore innovative ways to support STEM education and specifically the robotics-focused after-school activities in Prince George’s K-12 public schools. Approximately 30 College Park Scholars in engineering, computer science, public policy, and other majors take this course each semester and work with 150-200 K-12 students building robots in the local Prince George’s K-12
public schools a year. Since 2013, 325 College Park Scholars took this course. Had it not been for a limited number of open seats, more students would have taken the courses as reported by Dr. David Tomblin, the program director.

_data from FIRST Robotics Scholarships Awarded by the Clark School:_ Each year the Clark School of Engineering awards four FIRST Robotics Scholarships to admitted freshmen who are FIRST Robotics alumni. The following data provided by the Office of Undergraduate Recruitment and Scholarship Programs show the number of applications received in the past five years for this scholarship: 2015 - 51 applications; 2016 - 55 applications; 2017 - 60 applications; 2018 - 74 applications.

**Characteristics of Proposed Program**

**Educational objectives of program**

The proposed Robotics and Autonomous Systems (RAS) minor curriculum consists of advanced coursework in robotics and provides students with an opportunity to get a deeper exposure to specific aspects of robotics and autonomous systems. The mission of the Robotics and Autonomous Systems minor is to provide students with a foundation in robotics design and control, robotic programming, and perception and planning (ENME488*, ENAE488*, CMSC488*), and a practical robotics class where interdisciplinary groups of students develop real world robotic systems (ENEE488*). Note, the 488* designator refers to a temporary course number; permanent course numbers will be requested. The minor will introduce students to core robotics concepts—such as robot architecture, including sensors and actuators, robot design and integration, and control system design—as well as core robotic software concepts—such as algorithms, state event modeling, and programming. Students will also learn how robot hardware and software interact at the interface, for example, in sensing and control systems. With a minor in robotics engineering, students will not only receive preparation for entry into the robotics industry, but they will also become more effective at applying systems integration and engineering ideas in their chosen field. The RAS minor will consist of 12 credits of required advanced coursework in robotics (ENME488*, ENAE488*, CMSC488*, ENEE488*, or authorized substitutes), and six credits of elective class credits.

Consistent with University policy, students may not take any RAS minor requirements on a Pass/Fail basis and must earn a minimum 2.0 GPA in all courses required for the minor. The RAS minor must be completed simultaneously with a major degree program. At least four courses (the 4 required courses for 12 credits) completed for the RAS minor are not courses that may overlap with the major department. Elective courses (two courses for 6 credits) for the RAS minor may overlap with the major or another minor requirement.

The core courses may be opened to non-RAS students majoring in the department that offers the course, subject to the approval of the offering department and instructor.

**The academic curriculum for the RAS minor is designed to meet the following learning outcomes:**

- Students will demonstrate the ability to apply advanced technical skills required to approach and resolve problems in RAS through upper-level RAS-related coursework in computer science, engineering, and related disciplines.
- Students will be able to apply the broad interdisciplinary aspects of RAS, such as the design, control, programming, and integration of complex robotic systems.
- Students will obtain hands-on experience and demonstrate problem-solving skills in robotics through advanced coursework, experiential learning, and research.
• Students will gain a sophisticated understanding of the range of professional opportunities available in RAS as a result of first-hand interactions with RAS faculty and professionals.

Title for Transcript
Robotics and Autonomous Systems Minor

Primary Sponsoring Unit
Maryland Robotics Center, which resides in the Institute for Systems Research, A. James Clark School of Engineering. The Maryland Robotics Center facilities, including the Robotics Realization Lab in the Engineering Annex Building, will be utilized for core RAS courses requiring laboratory space and oversight.

Brief catalog description
The Undergraduate Minor in Robotics and Autonomous Systems is a cross-disciplinary program administered by the Maryland Robotics Center. The RAS minor is open to students in Mechanical Engineering, Aerospace Engineering, Electrical Engineering, and Computer Science majors. The minor takes a multidisciplinary approach to robotics in which students gain knowledge about many of the fields (design, control, programming, and integration) that intersect in robotics and autonomous systems. With an emphasis on hands-on experiences, students will gain practical skills through coursework, group projects, and research. Students will also have the opportunity to participate as peer mentors, tutors, and advisors. The minor program will also include regular interactions with academic, corporate and governmental leaders in robotics, who will serve as both mentors and professional contacts.

Program Oversight
The Maryland Robotics Center currently provides Technical Direction to the Office of Advanced Engineering Education Master’s of Engineering program in Robotics. With the introduction of the Robotics and Autonomy minor degree in Fall 2020, the Maryland Robotics Center will expand its educational offers to serve undergraduate students in engineering and computer science. To oversee the daily operations RAS program, the Maryland Robotics Center will add a dedicated staff position, the Robotics Education Coordinator. The RAS minor will also be supported by the MRC Educational Committee, which consists of engineering and computer science faculty. This committee will form the Interdisciplinary Leadership Council, to advise on curriculum development, potential instructors for the program, review admissions applications, and student plans for completion of the program.

General requirement for degree including total number of credits & their distribution
The RAS minor curriculum consists of advanced coursework in robotics and is designed to build on the strengths and competencies of the Maryland Robotics Center, which was launched in 2012. The RAS minor offers students an opportunity to gain a deeper exposure to specific aspects of robotics. The following table shows the RAS minor curriculum.

<table>
<thead>
<tr>
<th>RAS Minor (juniors/seniors)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Credit Hours</td>
<td>Minimum of 18 credits after prerequisites</td>
</tr>
<tr>
<td>Prerequisites</td>
<td>Math: Calculus I (MATH130, MATH140, MATH220) and Calculus II (MATH 141) and Differential Equations (MATH 246) or Dynamics ENES 221</td>
</tr>
<tr>
<td>Programming:</td>
<td></td>
</tr>
<tr>
<td>CMSC131 Object-Oriented Programming I or ENME 202/ENAE 202: Computing Fundamentals or ENEE 150 Intermediate Programming Concepts</td>
<td></td>
</tr>
<tr>
<td>Previous practical experience (such as internships and/or research) related to robotics is a plus on the application.</td>
<td></td>
</tr>
</tbody>
</table>

| Required Courses |
| ENME488* Introduction to Robotics: Modeling and Control |
| ENAE488* Robotic Programming |
| CMSC488* Perception and Planning |
| ENEE488* Robotic Project Class |

| Course Options (Electives) |
| Take at least **TWO** of the following 400-level courses: |
| ENME400 Machine Design |
| ENME410 Design Optimization |
| ENME461 Control Systems Lab |
| ENME4890 Micro/Nano Robotics |
| ENME489C Medical Robotics |
| ENME489L Bioinspired Robotics |
| ENME444 Assistive Robotics |
| ENME476 MEMS |
| ENME489B Mechatronics and the Internet of Things |
| ENME467 Engineering for Social Change |
| CMSC421 Intro to AI |
| CMSC422 Intro to Machine Learning |
| CMSC426 Image Processing |
| CMSC427 Computer Graphics |
| CMSC451 Design and Analysis of Algorithms |
| CMSC498F Robotics and Perception |
| CMSC828T Vision, Planning and Control in Aerial Robotics |
| ENEE440 Microprocessors |
| ENEE460 Control Systems |
| ENEE461 Control Systems Lab |
| ENEE425 Digital Signal Processing |
| ENEE408I Capstone Autonomous Robotics |
| ENAE380: Flight Software Systems |
| ENAE441: Space Navigation and Guidance |
| ENAE403: Dynamics of Flight |
| ENEE432 Control of Aerospace Systems |

**List of core courses by title and number**

The following list of core courses will be introduced to the respective department curricula by the associated faculty member. The Maryland Robotics Center will provide facilities and equipment for the laboratory courses, supervised by the Maryland Robotics Center Lab Manager and Facility Manager. Support for Teaching Assistants will be requested by the faculty instructor to the respective departments, on a case by case basis.

**ENME488*: Introduction to Robotics**

*Course Description:* This course will be intended as an introductory course to the robotics minor and will educate the students in the elementary concepts of robotics. The topics covered in the course will include mathematics of rigid motion, rotations, translations, homogeneous transformations, forward kinematics, inverse kinematics, velocity kinematics, geometric Jacobian, analytical Jacobian, motion planning, trajectory generation, independent joint control, linear control methods such as PD, PID, actuator dynamics, feedforward control for trajectory tracking, force control, basic computer vision concepts.
including thresholding, image segmentation, and camera calibration. This course will also include a laboratory component which will be conducted in the Robot Realization Laboratory in the Engineering Annex Building.

How different from other undergrad courses: There currently does not exist an introductory course that provides a gentle introduction to the various concepts in robotics including kinematics, manipulability, trajectory planning, independent joint control, computer vision. The other courses in the minor will emphasize some of these concepts in more detail.

Resources: This course will require an investment of $85,000 from the Maryland Robotics Center to buy the relevant manipulator arms. In addition, the MRC staff will facilitate the execution of the laboratory sections, initially to be offered in the Robotics Realization Lab in the Engineering Annex Building, and eventually moved to the IDEA Factory Robotics and Autonomy Lab.

Instructor: Axel Krieger and Nikhil Chopra
First Semester Offered: Fall 2020

ENAE488*: Robotic Programming
Course Description: This course introduces students to the Robot Operating System (ROS) as well as many of the available tools commonly used in robotics. Lectures will focus on theory and structure, whereas laboratory sections will focus on applications and implementations. Students will learn how to create software and simulations, interface to sensors and actuators, and integrate control algorithms. The course will work through exercises involving a number of autonomous robots (i.e., ground and air vehicles) that students could eventually use in their future robotics minor courses. Topics will include: ROS architecture, console commands, ROS packages, simulation environments, visualizations, autonomous navigation, manipulation, and robot vision.

How different from other undergrad courses: There are currently no existing undergraduate courses offering robotic programming using ROS and focusing on programming for real-world robotic systems.

Resources: We propose to use a shared lab space (e.g., Clark Hall) for lab sections of the course. Students will bring and use their own laptops.

Instructor: Mumu Xu. Other potential instructors: M. Otte
First Semester Offered: Spring 2021

CMSC488*: Perception and Planning
Course Description: This course teaches the fundamentals of robot perception and robot path planning. The syllabus and course is divided into two segments, as per the major aspects involved in robotics. There will be lectures on (a) planning and control and (b) perception, with projects and homework. The syllabus includes the following: Motion Planning Introduction, Rigid Body Transformations, Velocity, Velocity Dynamics, Vehicle Controls, Graph Based Planning, Sampling Based Planning, Trajectory Planning, Navigation, Baesyesian and Kalman Filtering, Camera Model and Calibration, Projective Geometry, Visual Perception features, Optical Flow, Pose Estimation, 3D Velocities, Basics of Machine Learning, Structure from Motion, Visual Odometry, and Recognition and Learning. There will be two examinations, 3 projects in multiple phases, and two homeworks. The class will use robots, mobile platforms with sensors and effectors. Drone experiments will be done in simulation or in the Iribe Drone Lab, space permitting.

How different from other undergrad courses: The class is different than the existing classes offered in Computer Science. First, there does not exist an undergraduate class on planning. There is an advanced class in computer vision (CMSC426), which also covers the material that is here in four lectures (lectures 13-16).

Resources: An investment of $50,000 will be made by the Maryland Robotics Center to support the
hardware/software needed for student projects. The hardware includes about 15 computer-controlled cars equipped with cameras and IMUs. Student projects will be performed initially in the Robotics Realization Lab in the Engineering Annex Building and, eventually, in the IDEA Factory Robotics and Autonomy Laboratory.

Instructor: Yiannis Aloimonos. Other potential instructors: D. Manocha, P. Tokekar, A. Srivastava
First Semester Offered: Fall 2021

ENEE488*: Robotics Project Class

Course Description: This practical robotics class teaches practical skills to build, control, and deploy robotic systems. Interdisciplinary groups of students will develop real world robotic systems. The first 10 weeks of the lab will be devoted to 5 pre-programmed experiments. The remainder of the lab will be devoted to student projects. We propose to have students work in teams of 2, preferably with each student coming from a different background in engineering. There will be 2 weekly lectures. The emphasis of the class is entirely on making a real robot do what you want it to do. In a first experiment students perform a simple servomechanism experiment, where students control a single joint of a robot. We vary the weight on the movable rod to simulate the effects of the changing inertia due to outer segments moving. Next, we have the students directly control several joints of a robot arm. The third experiment is to control the position and orientation of the end effector. A fourth experiment deals with grasping. A fifth experiment deals with the position and orientation of a wheeled robot.

Resources: We propose to initially use Room 3249 in the Kim Engineering Building, which the ECE Controls Lab now occupies, and utilize some of the existing equipment. Mr. Jay Renner, the lab engineer for the ECE Controls Lab, will initially support this course. The Maryland Robotics Center will purchase the robotic manipulators needed. For the mobile platform experiments, we plan to use the existing turtle bots in the RRL.

How different from other undergrad courses: This interdisciplinary class combines elements of all core RAS minor classes and reinforce those skills in practical experiments. This class is significantly different from ENEE408I Capstone Robotics and ENEE461 Control Systems Laboratory, since it combines building, control, and programming robotic systems and includes multi-DOF systems.

Instructors: William Levine. Other potential instructors: Pamela Abshire, Timothy Horiuchi
First Semester Offered: Spring 2022

Expected learning outcomes

Students will demonstrate the ability to apply advanced technical skills required to approach and resolve problems in RAS through upper-level RAS-related coursework in computer science and engineering disciplines.

- Students will be able to apply the broad interdisciplinary aspects of RAS, such as the design, control, programming, and integration of complex robotic systems.
- Students will obtain hands-on experience and demonstrate problem-solving skills in robotics through advanced coursework, experiential learning, and research.
- Students will gain sophisticated understanding of the range of professional opportunities available in RAS as a result of first-hand interactions with RAS faculty and professionals.

Program faculty and their credentials, explain advising structure for the program

The RAS minor will be administered by the Maryland Robotics Center team. The Technical Director of the program will be the Director of the Maryland Robotics Center, currently Derek Paley, Willis H. Young Jr. Professor of Aerospace Engineering Education. The MRC Director will be supported by a new MRC staff position, the Robotics Education Coordinator, to be filled in Spring 2020. The Education Coordinator will
oversee daily operations of the program, provide student advising, and supervise the application process. Applications will be reviewed by the MRC Educational Committee. The MRC Education Committee, composed of faculty members of the colleges involved in RAS, will advise on curriculum development, potential instructors for the program, admissions criteria, and student plans for completion of the program.

The RAS minor consists of newly created core classes ENME488* Introduction to Robotics: Modeling and Control, ENAE488* Robotic Programming, CMSC488* Perception and Planning, and ENEE488* Robotic Project Class, as well as established elective courses. The core classes are expected to be taught by Maryland Robotic Center instructors who are already on the faculty.

**Student audience to be served by program with enrollment estimates**
The RAS minor will be open to MechE, Aero, CS, ECE majors. The program as currently designed to handle 50 students in the first year. As external sources of support are cultivated, e.g., teaching assistants, the goal is to increase the yearly number of admitted students to 200 within 3 years.

The number of students admitted to the OAEE PMRO Robotics program has doubled over the past three years, from 85 in the Fall 2017 to 188 in Fall 2019. Given the interest in that program, we anticipate similar strong interest in the RAS minor and, furthermore, undergraduate students in the RAS minor may matriculate in the PMRO Robotics program, which could boost its domestic enrollment numbers.

**Procedures for admitting students into the minor**
The RAS minor will be a two-year program of advanced study in robotics for juniors and seniors. Students will apply during the early spring of their sophomore year (deadline will allow time for application review prior to registration deadline) to enter the program in the fall of their junior year and must meet all of the following requirements at the time of application to be eligible for consideration:

- Students of MechE, Aero, CS, ECE majors will be eligible to apply;
- Minimum of 30 university credits completed (sophomore standing; not including AP/IB credits);
- Strong academic record (minimum GPA of 3.0); and
- At least four semesters remaining at the University of Maryland prior to graduation.

- Previous practical experience (such as internships and/or research) related to robotics is a plus.

- Completed Prerequisites:
  - Math: Calculus I (MATH130, MATH140, MATH220); Calculus II (MATH 141); and Differential Equations (MATH 246) or Dynamics (ENES 221)
  - Programming: Object-Oriented Programming I (CMSC131) or Computing Fundamentals (ENME202/ENAE202) or Intermediate Programming Concepts (ENEE150)

Pre-selection of eligible applicants will be performed by MRC staff, led by the Robotics Education Coordinator. The MRC Education Committee will select the students for the minor among eligible applicants, based on the following department quotas, which has already been agreed to by the Undergraduate Study Directors of all four departments:

- Even among 4 Departments: 40%
- Proportionally to Department Enrollment: 50%
- Selection Committee Discretion: 10%

GPA is the main criteria for acceptance, along with relevant robotic experience and strong consideration for promoting diversity and inclusion.

**Facilities requirements & equipment**
Non-laboratory-based courses will be scheduled as per normal
procedure. For laboratory-based core courses, the Maryland Robotics Center will provide facilities and equipment as needed to support this educational initiative, subject to the availability of funds.

**Description of proposed means of offering the program (any components offered off-campus, online, in cooperation with another institution or through non-traditional schedule?)**

All courses are expected to be offered using a traditional schedule.

**Reliance on courses provided through other academic units—list the required courses & prerequisites along with letters from chairs or deans committing necessary seats**

There is no required course from other academic units. Two relevant courses from other units (as determined by program staff) may count as electives towards the minor.

**Library resources required**

No additional library needs are anticipated. While not a required resource, *The Robotics Science Journal* is available through the UMD library systems. The University subscription to the journal is paid for by the Maryland Robotics Center.
Robotics Program

Request for Proposals

Maryland State Department of Education
200 West Baltimore Street
Baltimore, MD 21201

Deadline
Monday, June 25, 2018
PROPOSAL DESCRIPTION

Name of Grant Program:
Robotics Program

Authorization:
House Bill 115 (2016)

Dissemination:
Friday, May 4, 2018

Deadline:
Monday, June 25, 2018

Purpose:
The State of Maryland is committed to helping local school systems maximize the potential of new and emerging technologies to improve student outcomes and better prepare all students for the workforce needs of the 21st Century. House Bill 115 (2016), Education-Robotics Grant Program – Establishment, created this program designed to increase the number of robotics programs in the state or to support existing robotic programs. To distribute these funds, the Maryland State Department of Education (MSDE) will make annual grants available to a school or to a nonprofit entity partnering with a school.

The robotics program or club may take place:
• Before or after the school day;
• On weekends and holidays; or
• During the school day.

Required Components:
To be considered for funding, proposals must include:

• Qualified key personnel, including club sponsor;
• Student access to essential technologies and materials;
• Activities aligned to recognized robotics standards, curriculum, or instructional programs;
• Schedule of meeting dates and location;
• Evidence of compliance with Local Education Agency (LEA) safety and privacy policies, including those related to non-system employees; and
• Equivalent access for students with disabilities regarding location, technologies, and digital resources.
Priorities:
Priority will be given to projects that incorporate one or more of the following:
- Schools and nonprofit partnerships, and/or
- Schools without existing programs.

Eligible Applicants:
- Public school with existing robotics programs,
- Nonprofit entity partnering with a public school to support an existing robotics program,
- Public school developing a robotics program, and
- Nonprofit entity partnering with a public school to develop a robotics program.

Proposal Review:
The review of proposals will be a two-part process.
1) Written applications will be pre-screened for submission requirements and inclusion of all required sections. Applicants not meeting all prescreen requirements will not be read.
2) A review committee established by the Maryland State Department of Education (MSDE) will evaluate written applications. The committee will be composed of representatives from outside agencies and MSDE personnel. Reviewers will comment upon the proposals and assign numerical scores based on a common rubric.

MSDE reserves the right to take into consideration geographic distribution when making awards.

Award Notification:
Notification of awards will be sent by mail on or about July 26, 2018.

Total Funds Available:
$250,000.00

Length of Grants:
July 31, 2018 – June 30, 2019

Estimated Number of Grants:
Twenty-five

Estimated Average Grant Amount:
$10,000.00
**Fund Use:**
Cost(s) incurred prior to the approval of the grant may not be funded through the award.

Fundable activities include, but are not limited to:
- Purchase of high level technology and equipment that support robotics program;
- Purchase of materials and supplies to support robotics programs;
- Substitute teacher fees or faculty stipends (stipends are allowable only for work performed outside the regular work day and based on LEA policy); and
- Enrollment and membership in robotics related competitions and organizations.

Non-fundable activities include:
- Construction of temporary or permanent structures;
- Membership to non-robotics organizations;
- Food or meals;
- Purchase of equipment for administrative purposes; and
- Renting or maintaining building space.

**The General Education Provisions Act (GEPA), Section 427:**
Each application must develop and describe the steps such applicant proposes to take to ensure equitable access to, and equitable participation in, the project or activity to be conducted with such assistance, by addressing the special needs of students, teachers, and other program beneficiaries in order to overcome barriers to equitable participation.

**Reporting Requirements:**
Grantees must submit:
- Quarterly project updates;
- Annual financial reports;
- A final evaluation report, due within 60 days of the end of the grant period.

In addition, grantees will host at least one site visit per funding cycle.
Proposals must contain the following information, assembled in the order indicated:

1. Proposal Cover Sheet.
2. Project Abstract.
3. Table of Contents.
4. Project Narrative (10-page limit).
   4.1. Extent of Need.
   4.2. Goals, Objectives, and Milestones.
   4.3. Plan of Operation.
   4.4. Evaluation and Dissemination Plan.
   4.5. Management Plan/Key Personnel.
      4.5.1. Management Worksheet.
      4.5.2. Project Time Line.
   4.6. Integration with Education Reform.
   4.7. Future Plans.
5. Budget Narrative.
   5.1. Line Item Listing of Budgetary Expenses.
   5.2. Itemized Budget Form.
6. Appendices. Do not append any required sections indicated above. Appendices are included below:
   6.2. Letters of commitment from all project partners and principals of participating schools (as appropriate).
   6.3. Résumés of Key Personnel.
   6.4. Signed assurances.
   6.5. LEA documentation or URL to policies related to safety and privacy, including those related to non-system employees

Submission Requirements:

- All pages of the project narrative must use one-inch margins and be numbered according to the prescribed numbering convention. (See “Table of Contents” section)
- The project statement that appears on the cover sheet must not exceed 100 words.
- The abstract must not exceed one page.
- Narrative must use line spacing of at least 1.5, and a type size of 12-point font. Charts may use single spacing and a type size of 10-point font.
- All copies of the proposal should be on standard size (8½” x 11”) paper of regular weight.
- Bound copies must be stapled in the upper left corner. They should not be bound by glue, spirals, wire, clasps, or any other means.
- The prescribed coversheet must be the first page of the proposal.
• The original coversheet must be signed in blue ink. Copies of the coversheet must not be color photocopied.
• Application package **excluding** proposal cover sheet, table of contents, budget narrative, itemized budget form, signed assurances and appendices must not exceed 20 pages.
• All tables and charts must follow prescribed formats.

NOTE: MSDE reserves the right to take into consideration geographic distribution when making awards.

**Submission:**

1. **An unbound original proposal, together with (5) bound copies sent to MSDE and postmarked by June 25, 2018. Use the address below.**

   Maryland State Department of Education  
   Instructional Technology and School Library Media Office  
   Science, Social Studies & Disciplinary Literacy Office  
   200 West Baltimore Street  
   Baltimore, MD 21201-2595

   Attention: Bruce Lesh and Val Emrich

2. **An electronic copy in .pdf format with original signatures, MUST be emailed on or before June 25, 2018 to:**

   Electronic copy should be sent by email to [valerie.emrich@maryland.gov](mailto:valerie.emrich@maryland.gov).

**Program Contacts:**  
Bruce Lesh, 410-767-0519  
[bruce.lesh@maryland.gov](mailto:bruce.lesh@maryland.gov)

Val Emrich, 410-767-0382  
[valerie.emrich@maryland.gov](mailto:valerie.emrich@maryland.gov)

**Financial Contact:**  
Kim Bellinger, 410-767-0448  
[kim.bellinger@maryland.gov](mailto:kim.bellinger@maryland.gov)

**Technical Assistance:**  
A technical assistance meeting will be held on May 14, 2018 from 10:00 a.m. - 11:00 a.m.

   Maryland State Department of Education  
   8th Floor, Conference Room 2  
   200 West Baltimore Street  
   Baltimore, MD 21201
The Maryland State Department of Education does not discriminate on the basis of age, ancestry/national origin, color, disability, gender identity/expression, marital status, race, religion, sex, or sexual orientation in matters affecting employment or in providing access to programs and activities and provides equal access to the Boy Scouts and other designated youth groups. For inquiries related to Department policy, please contact:

Equity Assurance and Compliance Office
Office of the Deputy State Superintendent for Finance and Administration
Maryland State Department of Education
200 W. Baltimore Street - 6th Floor
Baltimore, Maryland 21201-2595
410-767-0426 - voice
410-767-0431 - fax
410-333-6442 - TTY/TDD
PROPOSAL COVER SHEET

Every proposal must have a Proposal Cover Sheet. No other page may cover the proposal cover sheet. The subsequent information must be clearly stated in the following order:
• Name of applicant.
• Title of project.
• The words “Robotics Program”
• Name of contact person.
• Address of contact person.
• Telephone, fax, and email address of contact person.
• Project partners.
• Amount requested.
• Project statement (100-word limit).
• Dated signature of Superintendent of Schools/Head of Grantee Agency.
• Non-profit organizations only – include your Federal ID and DUNS#

The Project Cover Sheet should be printed on plain white paper and contain neither graphics nor additional information.

The project statement should briefly describe the project’s outcome(s) and strategies (i.e., what the project will do and how it will do it). Do not exceed the 100-word limit. This statement will be used in press releases, board exhibits, etc.

PROJECT ABSTRACT
1-page limit

In the Project Abstract introduce the project to the reader. It should be factual, brief, and focused on your efforts. Do not assume the reader is familiar with the proposed project.

The Project Abstract should cover the core aspects of the proposed project, while addressing the following questions:
• What is the problem?
• What populations, schools, or geographic areas will be served by the project?
• What are the goals and objectives of the project? (For brevity, these should be paraphrased.)
• What strategies are to be employed to address the problem?
• Who are the partners, and what are the roles of each?
TABLE OF CONTENTS

The Table of Contents is an important aid for the reader. When writing the proposal and constructing the table of contents, use the following conventions:

- The Proposal Cover Sheet is not numbered but is considered to be page “i” (lower case, Roman numeral one).
- The Project Abstract is page ”ii” (lower case, Roman numeral two).
- Do not list the Table of Contents as one of the pages in the table of contents.
- Table of Contents page(s) is (are) numbered iii, iv, etc.
- The extent of need is the first page of the project narrative and is numbered “1”. Subsequent pages are numbered consecutively.
- The Budget is numbered as follows: “B-1, B-2, B-3”.
- Appendices are labeled “Appendix A, Appendix B, Appendix C “.

PROJECT NARRATIVE

Ten (10), page limit 80 points for entire section

The Project Narrative provides an opportunity to convince readers that the project is sound and deserves to receive funding. The Project Narrative should encompass the entire life of the project. When writing the Project Narrative, keep the following suggestions in mind:

- Be succinct and clear. Readers need to understand quickly and easily the components of the project and how they work together to address the stated needs.
- Do not assume the reader is familiar with the project; readers represent diverse backgrounds. Avoid jargon, and define all acronyms.
- Proofread the Narrative once it is complete. Check for style inconsistencies, redundancies, factual omissions, and unexplained assumptions. A good strategy is to let someone not familiar with the project read and critique the proposal before submitting it to MSDE.
- Be as detailed as possible. Use the entire page limit to explain the project. Use the Appendices to include information that may be important for the reader but will not fit within the Project Narrative. For clarity, it is important to reference in the body of the proposal any supplemental information included in the appendices.
Extent of Need

A compelling proposal will have a clearly-defined problem supported by a needs assessment. A needs assessment is a systematic review of information collected from a variety of sources, analyzed to determine strengths and weaknesses, and prioritized for action in the proposal.

Here are some suggestions for the needs assessment.

- Clearly state the main problem in the first paragraph.
- Cite research supporting the need for the project.
- State what data were collected to confirm the existence of the problem, the sources of the data, and the methods used to collect them.
- State who is affected by the problem. State when and where the problem exists.
- Document the factors contributing to the problem.
- Document current or past efforts to address the problem.
- Show why those efforts failed or are inadequate to address the total need.
- Discuss the applicant’s history or expertise in dealing with the problem.
- Discuss the consequences of not dealing with the problem.

Goals, Objectives, and Milestones

Goals, objectives, and milestones are all outcomes. Outcomes are statements that tell how the project’s target population would improve. Every outcome should describe a change in a target population. In addition, outcomes set standards of progress towards alleviating the problems identified in the needs assessment. Statements that describe strategies or management issues are not proper outcome statements.

Outcome statements:

- **Identify the target population.** Who is the specific population the outcome addresses?
- **Are realistic.** Outcomes must be attainable. It is unrealistic to expect that all students will achieve 4.0 grade point averages. Unrealistic outcomes set your project up for failure and are “red-flags” for reviewers.
- **Are measurable.** Outcomes must demonstrate clear achievement. A good outcome statement references easily-quantified indicators (e.g., test scores, absenteeism, grades, promotion rates).
- **Have deadlines.** An outcome statement should specify when it is to be achieved.
- **Reference state, local, or school-defined baseline data or standards.** To determine if the goal is both reasonable and ambitious, include local baseline data for comparison.
This is an example of an outcome statement containing all of the above elements:

By January, 2019, 70% of high school seniors, in the three participating high schools, who were reading below grade level in the ninth grade, will achieve a rating of satisfactory on the district’s high school reading examination, a 20% increase over current levels.

A proposal should identify three kinds of outcomes: goals, objectives and milestones.

**The Goal**

State the overall goal of the project. The goal should address the main problem identified at the beginning of the needs assessment. While there should be at least one goal, it is possible to have multiple goals; however, the more goals established the more complex the project becomes.

Goals must have long-term deadlines. If the project period covers multiple years, the goal should be set for the end of the project. If the project period is one year or less, the goal may have a deadline that extends beyond the project period.

**Objectives**

Objectives are the anticipated outcomes to be accomplished for each year of the project. Objectives must be directly related to a goal. Objectives may break the long-term goal into steps or address the factors contributing to the problem addressed by the goal.

It is imperative that objectives be established for every target population the project is designed to affect. For instance, if the project seeks to increase student achievement by training teachers, there must be objectives for both students and teachers.

**Milestones**

Ongoing evaluation is essential to the management of a project. Since goals and objectives are not evaluated until the end of the year, milestones must be established to measure progress during the year. Milestones should be evaluated during the year, either quarterly or semiannually.

Because milestones are intended to indicate progress towards an objective, each milestone must be related to an objective. Keep in mind that milestones are indicators of progress, and may not use the same measurement tool as the objective to which they are related. A project may take months before there is a significant impact on clients, or the rate of improvement may level off over time. Milestones should anticipate this and be gauged accordingly. Don’t set overly-ambitious milestones.
Plan of Operation

In the Plan of Operation discuss the strategies and activities to be used to accomplish the outcomes.

**Strategies**

Strategies are broad approaches (methods, procedures, techniques) employed to accomplish outcomes. Begin this section with a justification as to why the strategies were chosen and how they will help to achieve the outcomes. The justification should cite research to support the strategies. It is essential that the project include strategies for each outcome, and outcomes for each strategy.

Upon identifying the strategies, discuss how they will be adapted to fit the particular project. Who are the target clients, and how will they use or be affected by the project services? How many clients from each client group will ultimately be serviced by the project, both directly and indirectly? Explain how these numbers were derived.

**Activities**

Activities are specific steps taken to accomplish the project objectives, and involve direct service to clients (students, teachers, parents). Examples include: specific teacher inservices, parent nights, and mentoring sessions. They may take place on a single date (e.g., a field trip), or over a period of time (e.g., the use of an innovative curriculum).

Actions outlined in the management plan are not activities. While these actions are needed to facilitate direct service, they do not render direct service themselves. Examples include the purchasing of equipment, the hiring of staff, evaluation procedures, and steering committee meetings. Do not address the elements of the management plan in this section.

List the activities that the project will implement and relate each activity to a strategy. Activities should be grouped with respective strategies. Discuss how the activities relate to the respective strategies. Finally, identify which clients and how many will be serviced by each activity.
Grantees are required to submit annual evaluation reports and quarterly progress reports that are consistent with the project’s goal and objective(s). Keep in mind that the final evaluation will consider the entire project, beginning to end. It should not be viewed as what is done after the project’s completion, but as an integral element in the project’s planning, design, and implementation. An effective ongoing plan that evaluates milestones quarterly lends to making informed decisions about needed changes.

**Evaluation & Dissemination Narrative**

The topics listed below provide the basis for review of the evaluation plan that should be addressed with specificity.

- **Evaluation Questions**: What questions will the evaluation seek to answer, based on the project’s goal and objectives, implementation plan, and anticipated consequences? Examine the relationship between the expected outcomes, efforts, and what is important to evaluate.

- **Evaluation Strategy**: What approach will be taken to find answers to the evaluation questions? What criteria will be used to assess lessons learned from the project? What populations will be included in the evaluation?

- **Data**: At minimum, data collection must include description of data collection plan that includes – frequency of meetings, number of competitions entered, total number of participants disaggregated into student groups, qualitative student reflections. There should be a combination of quantitative and qualitative data identified. How will project staff collect data from the various sites and organizations involved in the project? When considering data collection techniques, ensure that the resources are sufficient to use the proposed data collection techniques.

- **Evaluator(s)**: Specify the individuals or groups who will conduct the evaluation. What are the qualifications of each? What are the responsibilities of key personnel?

- **Budgeting of resources and staffing for evaluation**: The application’s budget should reflect sufficient funds to carry out a thorough and useful evaluation.

- **Dissemination**: Details on how the evaluation results will be disseminated to major stakeholders and individuals interested in the project. Information, requirements and dissemination methods differ from stakeholder to stakeholder. Will student involvement in competitions be highlighted? How and when will demonstrations of the project be provided? Descriptions of the types of reports and other by-products developed during the course of the project may be made available.
Management Plan/Key Personnel

Where many projects fail is in their management. Submit a detailed and time-specific management plan with pre-assigned responsibilities so as to avoid the following common errors:

• Failure to submit required reports.
• Failure to regularly monitor performance of the project during implementation.
• Failure to start the project on time.
• Failure to keep adequate project documentation.
• Failure to assure continuity and quality of the project in light of personnel turnover.
• Changing without approval from MSDE the overall project from that described in the grant proposal.
• Submission of biased or incomplete project evaluation data.
• Having no approved project fiscal procedure in place.
• Disposal of project supplies, equipment, or other assets in unauthorized ways.
• Budget deviations due to unauthorized transfers from one budget category to another.
• Failure to manage inherent conflicts of policies, perspectives, and philosophies between project’s host agency and the funder.
• Failure to form partnerships in which all members recognize and fulfill their clearly-defined roles, responsibilities, and contributions to the project.
• Failure to complete the project in a timely fashion.

**Partners:** Present a clear discussion of partners, their respective roles in the project, the benefits each expects to receive, and the specific contributions each will make to the project (financial, equipment, personnel, or other resources). It is essential that partner commitments be documented. Append letters of commitment from each, describing roles and quantifying contributions. Never assume that reviewers will automatically be familiar with a proposed partner, what that partner is capable of or willing to commit to the project, or why the partner is joining in on the project.

List the staff or personnel involved in the project’s implementation. What are their qualifications? Append résumés of key personnel. How much of the Project Director’s time is devoted to this project? Are there sufficient staff hours devoted to the project to ensure proper implementation? What plans are in place to ensure the project will continue if there are problems with staff turnover?
Management Plan Worksheet

The Management Plan supports the implementation plan but does not contain direct service activities. Direct service activities belong in the Plan of Operation. Examples of management actions are hiring staff, ordering equipment, developing curricula, and holding steering committee meetings. None of these actions render direct service itself, but enables direct service activities to take place.

List on the Management Plan Worksheet, in chronological order, all major management actions necessary to implement the project during the funding cycle. Assign an approximate date for each action. If the action is ongoing, indicate the range of dates over which it will be implemented. A well-considered management plan assigns responsibility for action to a management team member. Indicate on the worksheet who is responsible for accomplishing each action.

Requirements made by the funder, MSDE, should also be included in the management plan. These include the annual financial report, submission of progress reports to MSDE, and the final evaluation. The final report will serve as the final evaluation.

<table>
<thead>
<tr>
<th>Action Description</th>
<th>Date</th>
<th>Person Responsible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brief Description #1</td>
<td>Date</td>
<td>Name or Position</td>
</tr>
<tr>
<td>Brief Description #2</td>
<td>Date</td>
<td>Name or Position</td>
</tr>
<tr>
<td>Brief Description #3</td>
<td>Date</td>
<td>Name or Position</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Funder’s Requirements</th>
<th>Date</th>
<th>Person Responsible</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quarterly Report #1 Due</td>
<td>Date</td>
<td>Name or Position</td>
</tr>
<tr>
<td>Quarterly Report #2 Due</td>
<td>Date</td>
<td>Name or Position</td>
</tr>
<tr>
<td>Quarterly Report #3 Due</td>
<td>Date</td>
<td>Name or Position</td>
</tr>
<tr>
<td>Final Evaluation Process</td>
<td>Date</td>
<td>Name or Position</td>
</tr>
<tr>
<td>Financial Report Due</td>
<td>Date</td>
<td>Name or Position</td>
</tr>
<tr>
<td>Annual Evaluation Due</td>
<td>Date</td>
<td>Name or Position</td>
</tr>
</tbody>
</table>
Project Timeline

A Project Timeline is required that represents each month of the funding cycle. It should contain three sections: management, implementation, and evaluation.

Integration with Education Reform

If a project is to be successful, it must be aligned with the goals, efforts and plans of Federal, State, and local governments, as well as school improvement teams. This section illustrates how the project is part of overall education reform.

This section should address the following questions:
• How does this project help meet the goals and objectives of the School Improvement Team plan?
• How does this project fit into the LEA’s master plan?
• How does this project help meet State educational standards (e.g., MD College and Career Readiness Standards)?
• How does this project help meet national education goals or fit into national initiatives?
• How does project efforts coordinate with other projects currently underway?
• Are there plans for future projects that will coordinate with this one?
• Will resources be shared to increase efficiency and cost effectiveness?

Future Plans

Describe plans for continuing the project beyond the funding cycle. How will it be sustained after funding ends? Are there plans for maintaining the project’s partnerships?
BUDGET NARRATIVE

The project’s budget should detail every year of the project in a separate itemized budget for each year. It should demonstrate the extent to which the budget is reasonable, cost-effective, and integrates other sources of funding. All costs described in the project narrative will appear in the budget narrative and must have a corresponding entry in the itemized budget for that year.

Begin the budget with a narrative, justifying any line item expenses that are not obvious from the project narrative. Explain how line item costs were estimated, if the rationale is not obvious. Show how the budget is cost effective.

Immediately following the justification, include a line-item description using the format in the example below. Group line items according to the following categories: Salaries & Wages, Supplies & Materials, Other Charges, Equipment, and Transfers. Total each category.

Each line must be detailed and specific. General expenses should be broken down into specific line items. For example, “meeting expenses” can be broken down into competition fees, bus rentals, robotics kits and accessories. There is no page limit for the budget, so be as detailed as possible.

Clearly show the requested funds and in-kind contributions for each line item. Indicate the source of the in-kind contribution. Both requested and in-kind funds must be reasonable with current market prices.

Show how the expenses were calculated for each line item. Reviewers will use this information to determine if the budget is reasonable and cost-effective.

Use the format indicated by the following excerpt from a sample Budget Narrative.

<table>
<thead>
<tr>
<th>Line Item</th>
<th>Calculation</th>
<th>Requested</th>
<th>In-kind</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Salaries &amp; Wages</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Director based on salary</td>
<td>Stipend 8 mos. X 4 hrs. X $50</td>
<td>$800</td>
<td>$800</td>
<td>$1,600</td>
</tr>
<tr>
<td>Total Salaries &amp; Wages</td>
<td></td>
<td>$800</td>
<td>$800</td>
<td>$1,600</td>
</tr>
<tr>
<td><strong>Supplies and Materials</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LEGO NEW GEAR Pack</td>
<td>3 X $22</td>
<td>$66</td>
<td></td>
<td>$66</td>
</tr>
<tr>
<td><strong>Equipment</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lego EV3 Core Set</td>
<td>3 X $500</td>
<td>$1,500</td>
<td>$1,000</td>
<td>$2,500</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Registration Fees</td>
<td>FRC 1st Regional Rookie Additional Regional Event</td>
<td>$6,000</td>
<td></td>
<td>$6,000</td>
</tr>
<tr>
<td><strong>Total Direct Costs</strong></td>
<td></td>
<td>$8,366</td>
<td>$1,800</td>
<td>$10,166</td>
</tr>
<tr>
<td>Indirect Costs (3% of direct costs – (use LEA percentage)</td>
<td></td>
<td>$251</td>
<td></td>
<td>$251</td>
</tr>
<tr>
<td><strong>TOTAL Requested</strong></td>
<td></td>
<td>$8,617</td>
<td>$1,800</td>
<td>$10,417</td>
</tr>
</tbody>
</table>
Itemized Budget Form

The following page contains the itemized budget form that must be submitted with the application. If difficulties are encountered in categorizing the budget, consult with the financial agent in your local school system. This form must be signed by both your district’s Budget’s Officer and the Superintendent or designee.
<table>
<thead>
<tr>
<th>CATEGORY/PROGRAM</th>
<th>BUDGET OBJECT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>01 - SALARIES &amp; WAGES</td>
</tr>
<tr>
<td>201 Administration</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 21 General Support</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 22 Business Support</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 23 Centralized Support</td>
<td>0.00</td>
</tr>
<tr>
<td>202 Mid-Level Administration</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 15 Office of the Principal</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 16 Inst. Admin. &amp; Supv.</td>
<td>0.00</td>
</tr>
<tr>
<td>203-205 Instruction Categories</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 01 Regular Prog.</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 02 Special Prog.</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 03 Career &amp; Tech Prog.</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 04 Gifted &amp; Talented Prog.</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 07 Non Public Transfers</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 08 School Library Media</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 09 Instruction Staff Dev.</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 10 Guidance Services</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 11 Psychological Services</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 12 Adult Education</td>
<td>0.00</td>
</tr>
<tr>
<td>206 Special Education</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 04 Public Sch Instr. Prog.</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 09 Instruction Staff Dev.</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 15 Office of the Principal</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 16 Inst. Admin. &amp; Superv.</td>
<td>0.00</td>
</tr>
<tr>
<td>207 Student Personnel Serv.</td>
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</tr>
<tr>
<td>208 Student Health Services</td>
<td>0.00</td>
</tr>
<tr>
<td>209 Student Transportation</td>
<td>0.00</td>
</tr>
<tr>
<td>210 Plant Operation</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 30 Warehousing &amp; Distr.</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 31 Operating Services</td>
<td>0.00</td>
</tr>
<tr>
<td>211 Plant Maintenance</td>
<td>0.00</td>
</tr>
<tr>
<td>212 Fixed Charges</td>
<td>0.00</td>
</tr>
<tr>
<td>214 Community Services</td>
<td>0.00</td>
</tr>
<tr>
<td>215 Capital Outlay</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 34 Land &amp; Improvements</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 35 Buildings &amp; Additions</td>
<td>0.00</td>
</tr>
<tr>
<td>Prog. 36 Remodeling</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Total Expenditures By Object</strong></td>
<td>0.00</td>
</tr>
</tbody>
</table>

Finance Official Approval

Supt./Agency Head Approval

MSDE Grant Manager Approval
APPENDICES

The following Appendices must be included but not apply to the page limit of the Project Narrative. Include other Appendices as you deem necessary.

Works Cited

Use a standard format such as MLA or Chicago Manual of Style. Be consistent.

Letters of Commitment

Letters of commitment are required from all project partners, school principals and local education agencies participating in the project. A good letter should contain the following:

- A statement acknowledging and supporting the goal and objectives of the project.
- The participant’s expected gains from the project.
- The expertise, resources and financial contributions the participant is making towards the project. Financial contributions (in-kind and cash) should be quantified.
- A clear statement detailing the responsibilities of the partners.
- A clear statement that the partners intend to continue the partnership beyond the grant period.

Letters of commitment should be addressed to the superintendent or head of the grantee agency acting as the lead agency. Letters should not be addressed to MSDE. All letters should be included in the proposal and not sent directly to MSDE. Any letters sent directly to MSDE cannot be appended to the proposal.

Résumés of Key Personnel

Include a one-page résumé for each person playing a key role in the project. Only information relevant to the project should be included in the résumé.

Signed Assurances

The following page contains the assurances that must be signed and dated by the Superintendent of your school system or the head of your grantee agency. Please read all assurances carefully.
RECIPIENT ASSURANCES

By receiving funds under this grant award, I hereby agree, as grantee, to comply with the following terms and conditions:

1. Programs and projects funded in total or in part through this grant shall operate in compliance with State and federal statutes and regulations, including but not limited to the 1964 Civil Rights Act and amendments, the Code of Federal Regulations (CFR) 34, the Elementary and Secondary Education Act, Education Department General Administrative Regulations (EDGAR), the General Education Provisions Act (GEPA) and the Americans with Disabilities Act (ADA). Vendors, subgrantees, and/or consultants; including officers and employees shall comply with the Family Educational Rights  and Privacy Act at all times (20 U.S.C. §1232g).

2. Grantee shall assure that its facilities are accessible to individuals with disabilities as required by the ADA and applicable regulations. The grantee shall not discriminate against individuals with disabilities in the provision of its services and programs unless to do so would be an undue burden or result in fundamental alteration in the program as those terms are used in the ADA and its implementing regulation. The State reserves the right to inspect the grantee's facilities at any time to determine if the grantee is in compliance with ADA. The grantee shall bear sole responsibility for assuring that its programs conforms for the section 501c. of the ADA (42 USC 12201) as a bona fide benefit plan. The grantee shall indemnify and hold the State harmless in any administrative proceeding or action brought pursuant to the ADA for all damages, attorneys' fees, litigation expenses and costs, if such action or proceeding arises from the acts of grantee, grantee's employees, agents or subgrantees.

3. By accepting federal funds, the recipients certify that they have complied with Federal Executive Order 12549, Debarment and Suspension set forth in 2 CFR §180, and that, a signed Certification Regarding Debarment, Suspension, Ineligibility and Voluntary Exclusion form has been filed with Maryland State Department of Education Project Monitor.

4. Grantee shall establish and maintain fiscal control, fund accounting procedures by fund, as set forth in 2 CFR §200 and in applicable statute and regulation. By accepting federal funds, the recipient agrees that the amount of the grant award is contingent upon the receipt of federal funds. Grantee shall retain all records of its financial transactions and accounts relating to this grant for a period of five years, or longer if required by federal regulation. Such records shall be made available for inspection and audit by authorized representatives of MSDE.

5. Entities expending federal funds of $750,000 or more in a single fiscal year, must have an annual financial and compliance audit in accordance with 2 CFR Subpart F 200.500 et. seq.

6. The Maryland State Department of Education (MSDE) may, as it deems necessary, supervise, evaluate and provide guidance and direction to grantee in the conduct of activities performed under this grant. However, MSDE's failure to supervise, evaluate or provide guidance and direction shall not relieve grantee of any liability for failure to comply with the terms of the grant award.

7. Grantee shall adhere to MSDE reporting requirements, including the submission of all required reports. Failure to submit complete, accurate, and timely progress and final reports may result in the withholding of subsequent grant payments until such time as the reports are filed.

8. Grantee must receive prior written approval from the MSDE Program Monitor before implementing any programmatic changes with respect to the purposes for which the grant was awarded. Unless a division implements a stricter policy, grantee must receive prior written approval from the MSDE Program Monitor for any budgetary realignment of $1,000 or 15% of total object, program or category of expenditure, whichever is greater. Grantee must support the request with the reason for the requested change. Budget realignments must be submitted at least 45 days prior to the end of the grant period.

9. Requests for grant extension, when allowed, must be submitted at least 45 days prior to the end of the grant period.

10. Grantee shall insure that programs and projects that offer web-based or technology band instructional products or programs which are funded in total or in part through this grant will operate in compliance with Section 508 of the Federal Rehabilitation Act of 1973 as amended and Section 7-910 of the Education Article, Annotated Code of Maryland.

11. Grantee shall repay any funds that have been determined through the federal or State audit process to have been misspent, misapplied, or otherwise not properly accounted for, and further agrees to pay any collection fees that may subsequently be imposed by the federal and/or State government. The repayment may be made by an offset to funds that are otherwise due the grantee.

I further certify that all of the facts, figures and representations made with respect to the grant application and grant award, including exhibits and attachments, are true and correct to the best of my knowledge, information, and belief.

Superintendent of Schools/Head of Grantee Agency                       Date
Robotics and Autonomous Systems (RAS) Minor Student Interest Survey
99 responses

1. What is your major?
99 responses

Aerospace Engineering: 17 (17.2%)
Electrical Engineering: 11 (11.1%)
Computer Science: 11 (11.1%)
Mechanical Engineering: 44 (44.4%)
Computer Engineering: 10 (10.1%)
Engineering: Undecided: 1 (1%)
Physics: 1 (1%)
Bioengineering: 1 (1%)
Bioengineering: 1 (1%)
Studio Art: 1 (1%)
Fire Protection Engineering: 1 (1%)
Materials Science and Engineering: 1 (1%)
Undecided but interested in Mechanical Engineering: 1 (1%)
MatSci: 1 (1%)
Civil Engineering: 1 (1%)
If a robotics and autonomous systems minor (RAS) were available to you, would you pursue it? The RAS minor will be a two-year program of advanced study in robotics for juniors and seniors and will require a minimum of 6 courses, 4 core courses, and 2 electives. The 2 elective courses for the minor may overlap with the student’s major or another minor.

99 responses

If you answered "No" to question 3, you may skip to question 7. Otherwise, please answer all of the remaining questions.
4. What coursework would you be interested in as part of the robotics minor? Check all that apply.

96 responses

- Programming: 67 (55.8%)
- Artificial Intelligence: 65 (67.7%)
- Computer Vision: 65 (67.7%)
- Control: 55 (57.3%)
- Sensors and Actuators: 65 (67.7%)
- Micro/Nano Robotics: 55 (57.3%)
- Laboratory Experiments: 55 (57.3%)
- Independent Research with Robotics Faculty: 63 (55.2%)

5. What programming languages and software would you like to develop skills in through coursework in the robotics minor?

95 responses

- Python: 70 (73.7%)
- Java: 32 (33.7%)
- C/C++: 83 (87.4%)
- Microcontroller languages: 47 (49.5%)
- MATLAB/Simulink: 41 (43.2%)
- LabVIEW: 48 (50.5%)
- Computer Aided Design Software: 43 (45.5%)
- Robot Operating System (ROS): 1 (1.1%)
6. How important to you are the following potential benefits of the robotics minor?

7. Would you sign a petition addressed to engineering administrators advocating for the creation of a robotics minor?

99 responses
Robotics Minor Proposal

We, the students of the A. James Clark College of Engineering, propose the creation of a Minor in Robotics. The purpose of this minor is to teach students how to conceptualize, design, program, and build robots. This minor immerses students in the robotics industry and research community, so they emerge able to create disruptive innovations within the field. Students enrolled in the robotics minor complete a 15 credit, project-intensive curriculum which is comprised of the following three course levels.

The first level is a new introductory course into the theory and development of robotics. Students in this course work in small cross-disciplinary teams to develop a standardized robotics project, such as building and programming a robotic arm, over the course of the semester. Leveraging a flipped classroom model, students use classroom time to work on the project, and learn robotics concepts as assignments. Students emerge with experience in the fundamentals in mechanical prototyping, systems integration, and computational controls.

In the second level students choose 2-3 elective courses in specialized robotics topics. These technical electives are chosen from existing robotics courses offered on the undergraduate level, as well as courses currently offered through the master’s level robotics program. Students emerge with specialized knowledge in their intended core robotics field, enabling complete execution of their senior capstone project. To allow for flexibility in completing the minor, students have the ability to complete levels 2 and 3 simultaneously.

The third level is a capstone robotics project in a student’s core field of interest. This requirement is fulfilled in a number of ways, giving students the flexibility to pursue their specialization in cross-disciplinary teams of their choosing. Projects include: pursuing independent research, developing a product with intent to commercialize, producing significant advancement within existing faculty research, forming a team to compete in national robotics challenge, or any significant robotics project students intend pursuing. If the student’s role within the project has significant overlap with their major field and is of a comparable depth and intensity, students can double count this course for fulfillment of their major engineering capstone course. The capstone project represents the final product of the students’ robotics education. The innovations produced demonstrate the students’ ability to think forward and creatively solve problems with real world applications, attracting attention from employers, universities, and the Maryland community.

The robotics minor enables a new wave of undergraduate research. Passionate students translate research into new opportunities for high-tech entrepreneurship. Maryland will be the first choice of current and future industry leaders needing experienced engineers to fuel the fast growing field of robotics. By being one of the first public universities in the nation to offer undergraduate robotics education, Maryland will once again prove itself to be a leader in preparing students to innovate on the forefront of technology.

Already over 50 students and a number of engineering faculty have expressed significant interest and direct intent to participate in the minor if it is offered. Robotics is clearly an area of significant interest at this university, and the creation of this minor catalyzes the achievement of Maryland students in this rapidly growing field. The minor produces true leaders in the industry who are driven to immediately innovate in the field of robotics. By supporting this proposed minor, the University furthers its goal of being on the leading edge of innovation.