Princeton University

Honors Faculty Members Receiving Emeritus Status

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Faculty Members Honored in 2020
for Receiving Emeritus Status

Robert Stengel

Robert "Rob" Stengel has been a professor of mechanical and aerospace engineering at Princeton since 1977. He will transfer to emeritus status at the end of the 2019–20 academic year. Rob developed a passion for science and aviation while growing up in Millburn, New Jersey. After graduating from the Massachusetts Institute of Technology with a degree in aeronautics and astronautics in 1960, he spent the next three years as an aerospace technologist with the National Aeronautics and Space Administration. For most of that time he was on active duty as a U.S. Air Force lieutenant, serving as a range safety officer at NASA's Wallops Island, Virginia, rocket launch site. Rob married his college sweetheart, Margaret ("Pegi") Ewing, in 1961.

Rob came to Princeton as a graduate student in mechanical and aerospace and science in 1963, intent on earning a M.S.E. degree and leaving to work on the Apollo Program. At the urging of his professors, Enoch Durbin, Dunstan Graham, and Edward Seckel, he stayed to add his master's and Ph.D. degrees. He conducted experimental research on high-altitude wind profile measurements that led to his thesis and a patent. Relieved that the U.S. had not reached the moon by his 1968 graduation, Rob joined the Digital Autopilot Group at the M.I.T. Instrumentation Laboratory (I-Lab), where the Apollo Guidance System was conceived and implemented. There he designed the Lunar Module's (LM) manual attitude control system, which allowed Neil Armstrong and five others to fly to the lunar surface. One line of the control code on which they relied was labeled "Pegi."

Once the LM control design was completed, Rob turned his attention to other I-Lab projects. He created a preliminary design for the Space Shuttle Atmospheric Control System, facilitated the installation of an Apollo computer in the world's first supersonic digital fly-by-wire (DFBW) airplane, analyzed the flight stability of supersonic transports, and conceptualized a bedside biomedical computer, a forerunner of today's laptop-based EKG systems.

Rob left the I-Lab (now called Draper) in 1973 to join The Analytic Sciences Corporation, a small entrepreneurial company on the outskirts of Boston. He led a small group of engineers that conducted research on a variety of topics, principally aircraft flight control but also submarine control, rail vehicle dynamics, and the environmental impact of electric

power generating plants. His group also designed a DFBW system that was flight tested in an experimental NASA helicopter.

In 1977, Rob returned to Princeton as an associate professor of aerospace and mechanical Sciences and director of the Flight Research Laboratory. He was granted tenure in 1980 and promoted to professor two years later. The flight lab operated five experimental aircraft and several hovercraft from the airfield on the Forrestal Campus. One of the first projects that Rob, his students, and staff carried out was to build a microprocessor-based control and data acquisition system that converted two analog fly-by-wire airplanes to DFBW, certainly the first small aircraft to have such systems. The computer also was used to acquire high-angle-of-attack, unsteady aerodynamic measurements on sailplane flight tests and as a test platform for fiber-optic transmission of air data from wingtip sensors to the aircraft's controller. His research was funded by NASA, FAA, Office of Naval Research, Army Research Office, and generous Princeton alumni. Nevertheless, funding for university flight research is never assured, and priorities of funding agencies change. Lack of external support closed the flight lab in 1983.

Rob taught graduate courses on flight dynamics and automatic control in his first year on the Princeton faculty. In following years, he taught an undergraduate special topic course on aircraft guidance and control, and he created the long-running space flight engineering course. The space course morphed into the two-term sequence at the core of the spacecraft track for students in the MAE department's undergraduate aerospace program. Teaching the space system design component while the regular instructor was on sabbatical in 2016, Rob focused the assignments and term paper on defending the Earth from an asteroid impact.

The two-term graduate aircraft flight dynamics course was downsized to a one-term undergraduate course, a core component of the aerospace program's aeronautical track. At about the same time, Rob created Princeton's first graduate course on optimal control and estimation. Via lecture slides posted on the web, this course has become the basis for similar courses around the world.

During his three-year term as associate dean for academic affairs in the School of Engineering and Applied Science, Rob was granted a reduced teaching load; he used this opportunity to create the first engineering freshman seminar, "From the Earth to the Moon." In a significant innovation, course notes for the seminar were text combined with executable Mathematica computer code. In this seminar's last three offerings, first-year students created credible preliminary designs for robotic lunar landers.

After stepping down as associate dean, Rob created the undergraduate course "Robotics and Intelligent Systems," filling a large gap in the undergraduate curriculum. He directed a certificate program of the same name with over 350 students receiving the certificate at graduation. The course and program preceded the current SEAS initiative on robotics and cyber-physical systems by two decades. Rob has advised 46 graduate students and post-docs as well as over 100 senior thesis students. Many pursued careers in industry, research, and academia, several became test pilots, and one became an astronaut. Mark Psiaki, a former Stengel PhD student and the Kevin Crofton Faculty Chair in Aerospace and Ocean Engineering at Virginia Tech, credits Rob with greatly sharpening his own writing skills. Psiaki notes that Rob's profusion of red ink inspired him to do the same with his students, and that this trait has been passed on to his students' students with many positive outcomes including two NSF career awards.

Rob has written two books and has authored or co-authored over 100 archival papers and 160 conference papers. Among his most cited works are seminal papers on nonlinear dynamic inversion, robust control of hypersonic aircraft, and smooth function approximation using neural networks. He and his students have laid the groundwork for applications of artificial intelligence in control, failure-tolerant control, heuristic dynamic programming for adaptive control, optimized air traffic control, and safe flight through microburst wind shear. His books, *Optimal Control and Estimation* (1986) and *Flight Dynamics* (2004), currently are the second and third best-sellers in their fields. Rob is preparing a second edition of *Flight Dynamics* with added emphasis on control systems. He has established an Internet presence, with 100,000 visits to his website and half a million file downloads of lecture slides and papers in the most recent year. Rob has been a visiting scholar at seven universities and a visiting member of the Institute for Advanced Study. He has given over 30 invited lectures; served on numerous professional, state, and federal committees; been an expert consultant for 20 organizations; and testified twice before Congress regarding aerospace research.

Rob has had an abiding interest in applications of engineering techniques to biomedical problems since his days at the I-Lab. He and his students wrote a series of papers on the optimal enhancement of immune response to infection, as well as on mutation and control of HIV. Another paper models the dynamics of "cytokine storms," the critical element in sepsis and a major factor in the acute respiratory distress associated with COVID-19 infection. He was co-principal investigator

for bioinformatics in a multi-institutional NIH Program Project Grant to develop new methods for colon cancer detection.

Rob views engineering and engineering education as the noblest of professions, translating mathematics and science into applications that serve humanity. He is not content to find a fact; he needs to know that it has some useful purpose. Nor is he content to be the final user of the fact. He is grateful for having had the opportunity to contribute at the intersection of knowledge and technology, to learn from and to educate students, and to take an idea from one field and apply it in another. To Rob, engineering is quite clearly the optimal career solution.

Rob is a Life Fellow of the Institute of Electrical and Electronics Engineers and a Life Fellow of the American Institute of Aeronautics and Astronautics. He has received the AIAA Mechanics and Control of Flight Award, the AIAA Pendray Aerospace Literature Award, and the John R. Ragazzini Education Award of the American Automatic Control Council. He is a co-recipient of the FAA's first Excellence in Aviation Award. Rob and Pegi are beginning their 60th year of marriage.