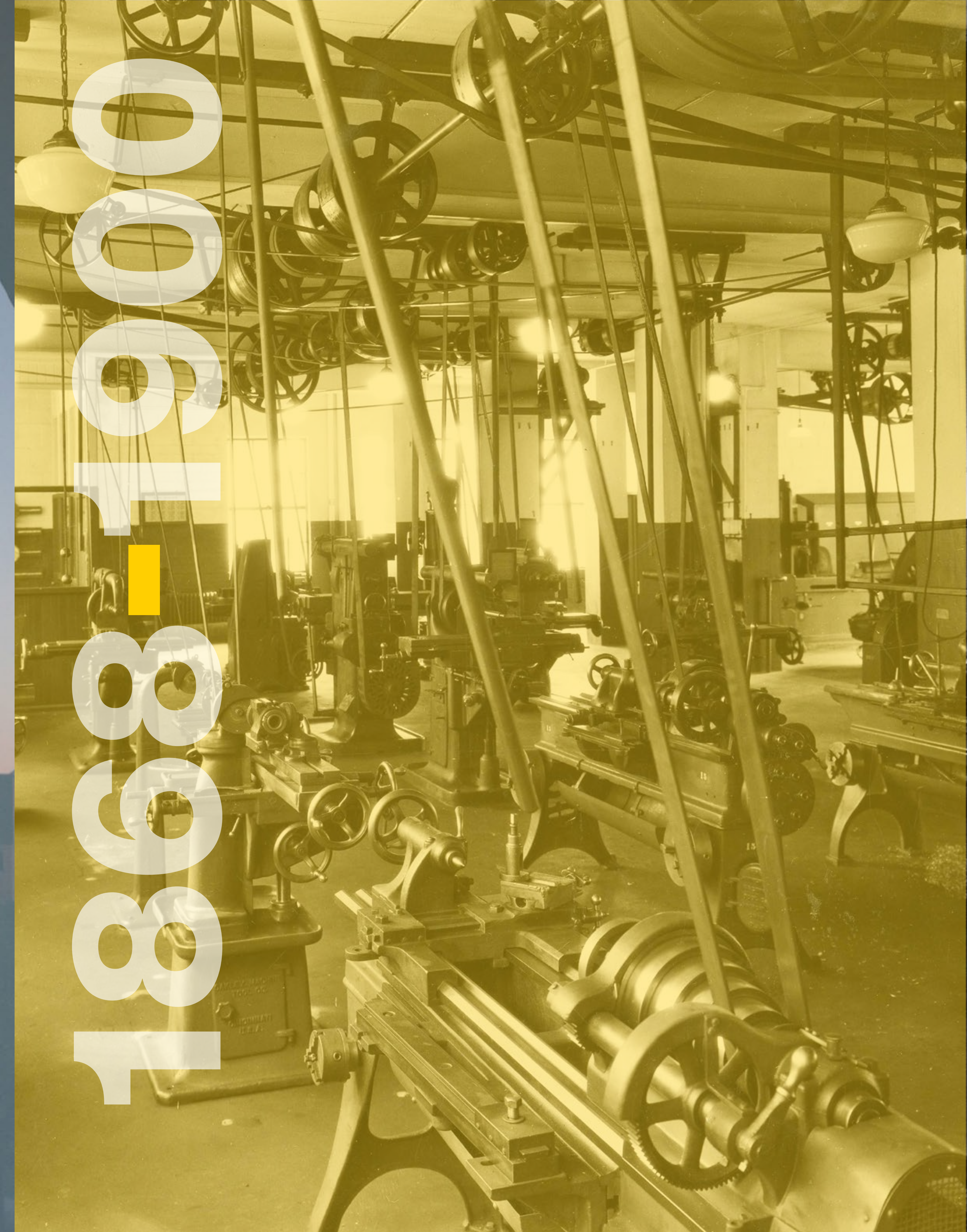

1868 2018
150 YEARS IN REVIEW
CELEBRATING
150
YEARS
1868 M 2018
MECHANICAL ENGINEERING

1868–1900



From its humble beginnings in 1868 as a two-room laboratory with one professor, the University of Michigan (U-M) Department of Mechanical Engineering (ME) has become one of the world's top mechanical engineering programs, with a rich history and a strong, clear vision for the future. We continue to shape the field by conducting innovative impactful research and generating new paradigms as well as achieving education excellence and developing future leaders.

1868-1900: CREATING THE DEPARTMENT

In 1868, the only formal engineering curriculum was in civil engineering, and the American Society of Mechanical Engineers (ASME) would not be established until a dozen years later. U-M professors DeVolson Wood and Stillman Robinson asked the University to offer a separate course to focus on the new fields of machine, power and marine engineering. The regents voted in 1868 to create the program, the first of its kind in the U.S., but the University lacked the resources to maintain it, and it was reabsorbed two years later into civil engineering.

It wasn't until Mortimer E. Cooley, a naval officer, came to Ann Arbor in 1881 that ME at Michigan gained an independent identity. Cooley, an 1878 graduate of the U.S. Naval Academy, was one of a number of naval officers appointed by Congress to university facilities. His assignment was to establish an ME program. Over the next three decades, his leadership laid the foundation for a thriving department.

The initial ME curriculum consisted of Workshop Appliances and Processes; Pattern Making, Moulding and Founding; Mechanical Laboratory Work (Shop Practice in Forging); Machinery and Prime Movers (Water Wheels and Steam Engines); Machine Design; Thermodynamics; Original Design; Estimates, Specifications and Contracts; and Naval Architecture.

At that time, engineering classes were held in the South Wing of University Hall, but there was no laboratory building. To remedy that situation, Cooley used an appropriation of $2,500 from the State of Michigan legislature to construct and equip a two-story laboratory building. A contemporaneous account describes as a " a two-story structure of frame construction with bricks placed edgewise between the studding. The building was heated by an old-fashioned stove on the second floor. In cold weather, ice was melted in a pail of water on top of the stove in order to increase humidity." The new facility contained a foundry, a forge shop, brass furnace, and engine room on the first floor, and a pattern shop and machine shop on the second floor.

THE BLACKSMITHING AND MACHINE TOOL SHOP (SECTION DIVIDER) INCLUDED ITS OWN POWER PLANT AND LINE SHAFTS POWERING THE BELT-DRIVEN MACHINES.

THE FIRST MECHANICAL LABORATORY (ABOVE) WAS BUILT FOR $2,500 IN 1882, IT HOUSED A FOUNDRY, FORGE ROOM, BRASS FURNACE, ENGINE ROOM, MACHINE ROOM AND PATTERN SHOP.

DEPARTMENT CHAIRS

1881 to 1904: Mortimer E. Cooley
1904 to 1917: John R. Allen
1917 to 1937: Henry C. Anderson
1937 to 1940: John E. Emswiler
1939: Ransom S. Hawley (Interim)
1940 to 1951: Ransom S. Hawley
1951 to 1955: Edward T. Vincent
1955 to 1956: Wyeth Allen
1956 to 1965: Gordon Van Wylen
1965 to 1966: Arthur Hansen
1966 to 1974: John A. Clark
1974 to 1975: J. Raymond Pearson (Interim)
1975 to 1978: J. Raymond Pearson
1978 to 1981: David Pratt
1981 to 1982: Richard E. Sonntag (Interim)
1983 to 1992: Richard E. Sonntag
1992 to 1998: Panos Y. Papalambros
1995: James R. Barber (Interim)
1998 to 2001: A. Galip Ulsoy
2001 to 2007: Dennis N. Assanis
2007 to 2008: Panos Y. Papalambros (Interim)
2008 to 2018: Kon-Well Wang
2018 to present: Ellen Arruda

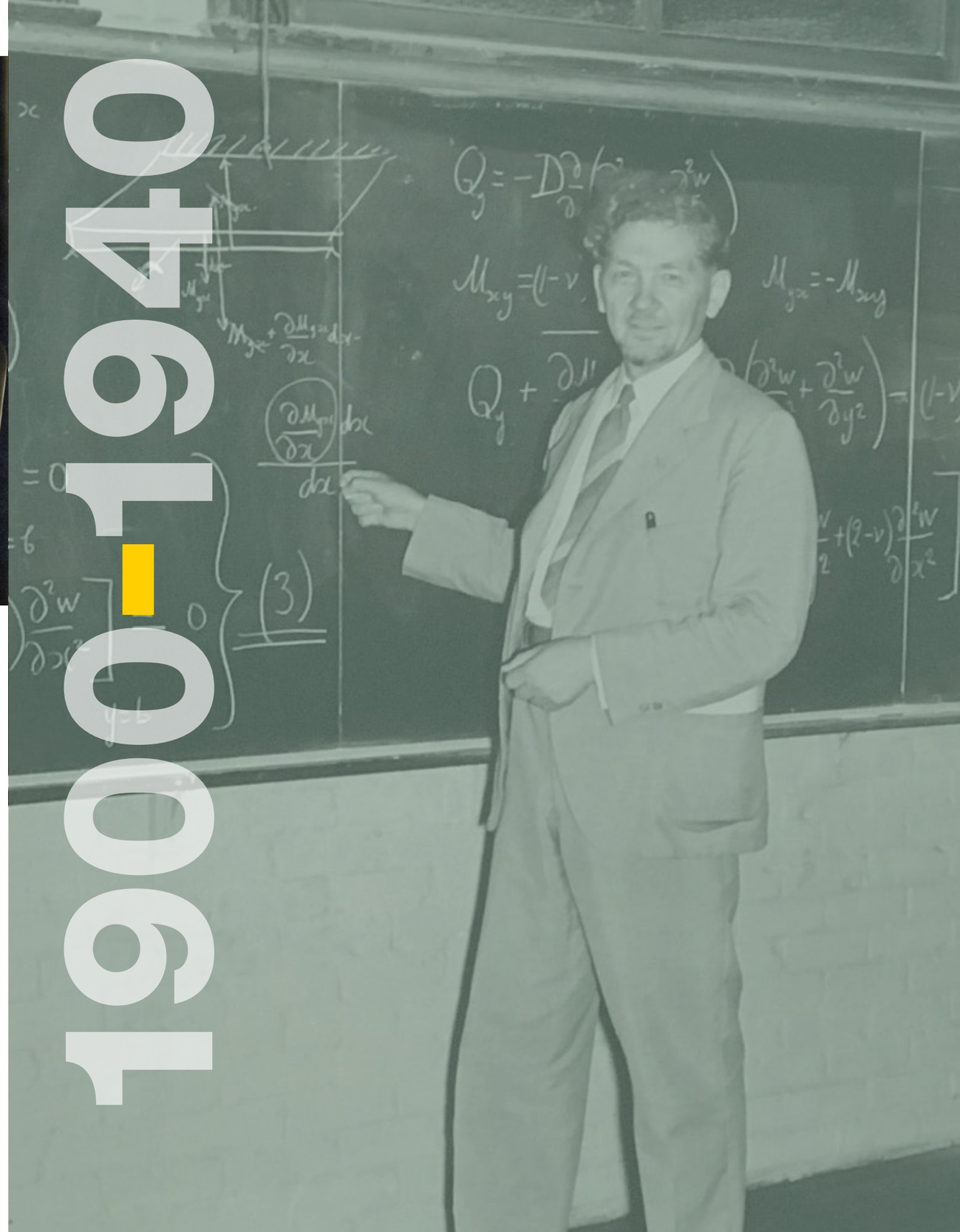
MORTIMER E. COOLEY, U-M ME DEPARTMENT CHAIR FROM 1881-1904.

"How well I remember my first class in this little shop. Six engineers were taking the course. The first lesson was at the forge. I taught them how to build a fire. Then I wanted a piece of iron to heat. At the back door there was a wagonload of scrap of different kinds of metal, and I sent the members of the class to bring me back a piece of wrought iron. Much to my surprise not one of the six could identify wrought iron, cast iron, steel, or anything else in the pile. I asked the differences between the various kinds of metal, and every last one of them knew the chemical differences and the process of manufacture, but not one of them could identify one piece of metal from another. That incident thoroughly convinced me of the need from practical work to acquaint engineers with the characteristics of the materials they would be using after graduation."

—from *The Scientific Blacksmith* (1947) by Mortimer E. Cooley

Cooley and other faculty also arranged for students to make visits to neighboring businesses. An entry in the University catalogue of 1890 explains: "As often as may be practical, visits will be paid to the neighboring manufacturing establishments for the purpose of acquiring a knowledge of the methods employed in building and in the construction of bridges, machinery and ships. In the spring of 1886, members of the classes in civil and mechanical engineering spent a week, under the guidance of Professor M.E. Cooley, in visiting industrial works at Detroit, Cleveland and Pittsburgh."

During the 23 years of the Cooley era, the Department acquired a strong curriculum, launched its first successful building program, and formed a strong relationship with business and industry. In 1904, Cooley was named dean of the College of Engineering, a post he held for the next 24 years.



With a strong foundation built during the Cooley era, the ME Department—as well as the entire engineering program at U-M—was primed to step into a leading role in engineering education in the 20th century. Drawing students from across the country and throughout the world, the engineering student body grew tenfold over the next 40 years; graduate degrees were offered for the first time; labs were updated and equipped with modern instrumentation; and independent research projects became important academic endeavors. The University strengthened its relationships with industry and other schools, and interdisciplinary joint-degree programs with law and business were created. The Department grew from a fledgling organization to one of the nation's leaders in mechanical engineering education.

1900-1940: BUILDING NATIONAL PROMINENCE

CURRICULUM

In the 1800s, ME had emphasized steam power and manufacturing machinery almost exclusively. But the world of science and industry was changing, and the Department changed with it.

In 1910 Felix Pawlowski, a young scientist from Poland, arrived in the U.S., determined to become America's first aeronautical engineer. But when he sent letters to engineering colleges around the country asking to be given the chance to start an aeronautics program, he received mostly negative replies: the field was too new and there was no assurance that it would amount to anything. But Mortimer Cooley was visionary. He appointed Pawlowski to the ME faculty and encouraged him to create an aeronautical engineering course of study. The first of its kind in the U.S., the new course debuted in 1914, just 11 years after the Wright brothers' historic first flight at Kitty Hawk, with the first degree awarded in 1917.

FACILITIES

As the Department grew, the need for advanced facilities grew with it. In 1904, West Engineering—the building that would become the symbol of Michigan engineering—was constructed. Now known as West Hall, the building's laboratories were among the most sophisticated in the country at the time.

The equipment in the General Mechanical Engineering Laboratory included steam power machinery; internal combustion engines; and air compressors, among other items. The Hydraulic Lab, which occupied a 40-by-60-foot space on two floors, featured a canal that conveyed water from the naval tank to a well that furnished the suction supply for the pumps. The Physical Testing Laboratory tested materials for strength. And the Highway Laboratory tested materials used in road construction.

STEPHEN P. TIMOSHENKO (SECTION DIVIDER) BECAME KNOWN AS THE WORLD'S LEADING AUTHORITY IN APPLIED MECHANICS.

AUTOMOTIVE ENGINEERING

ME's program in automotive studies began at about the same time as the auto industry did, offering its first course, Gasoline Automobiles, in 1913.

By 1914, ME had gained a strong reputation in automotive engineering, and as World War I began the Department was called upon by the government to help in the war effort. Over the next few years, ME faculty trained 1,081 Army personnel in automotive engine repair.

In 1916, Walter Lay joined the ME faculty with a mandate to create a lab and a slate of automotive courses. The Walter E. Lay Automotive Laboratory is a good example of how the Department responded to new directions in industry. Lay partnered with automotive manufacturers to carry out pioneering research. The lab was one of the first to present comprehensive experimental data showing the advantages of streamlining, and undertook other studies to determine optimal highway grades, explore engine heat balance, test and improve automotive parts, and improve car safety, car noise and riding comfort.

INDUSTRIAL AND PRODUCTION ENGINEERING

The auto industry established southeastern Michigan as the home of U.S. manufacturing, with world-changing innovations such as the assembly line and interchangeable parts. In response to a dramatic evolution in industrial practices and processes, the Department created a program on the leading edge of the discipline. Scientific Shop Management, introduced in 1915, featured the study of applications of scientific management in manufacturing plants. During World War I, it was expanded to include two courses in training of officers of the Ordnance Department of the Army – the first such course offered by an American university.

ORLAN W. BOSTON AND MANUFACTURING SCIENCE

In 1921, Orlan W. Boston joined the faculty. Cooley assigned him the task of developing courses that would combine the disciplines of design, metallurgy and production. The Department soon was playing a major role in establishing the scientific basis for manufacturing processes. In 1934, Boston was named chair of the Department of Metal Processing in 1934, and in 1936 was named Custodian of the Gaging and Measuring Laboratory of the Detroit Ordnance District. By 1936, enrollment in metal processing courses was so large that crowded sections were taught every half-day during the week.

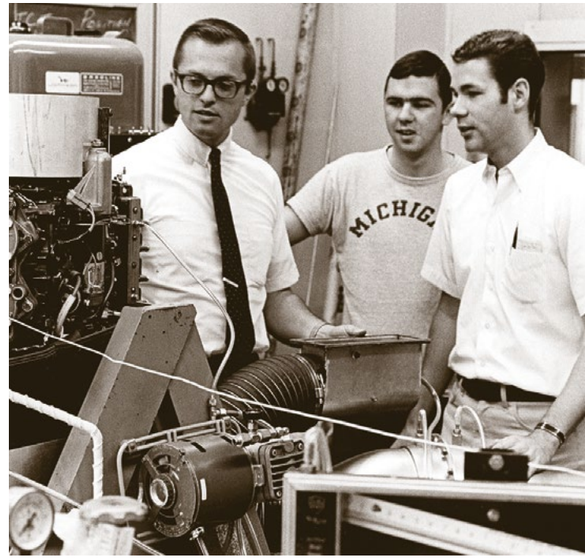
STEPHEN P. TIMOSHENKO AND APPLIED MECHANICS

Stephen P. Timoshenko was a member of the faculty from 1927 to 1936, who became known as the world's leading authority in applied mechanics. His work gave birth to the science-based engineering education that is now the standard all over the world. Timoshenko delineated the essential rules for how structures deform under stress, established the foundations of the theory of the elastic behavior of solid matter and introduced scientific and mathematical approaches to mechanics instruction. Under his leadership, Michigan became the first university in the nation to offer bachelor's and doctoral programs in engineering mechanics.

Timoshenko also introduced scientific and mathematical approaches to the teaching of mechanics. During his tenure, U-M established the first bachelor's degree program in engineering mechanics in the nation as well as the first doctoral degree. During the course of his career, Timoshenko wrote 18 textbooks that were translated into 36 languages. He was the recipient of numerous honorary degrees, and in 1948 the ASME named a medal after him to honor his contributions.

By 1940, the Department was well established as one of the leading mechanical engineering programs in the country. The production engineering group carried out world-recognized research for the War Production Board during World War II.

The years immediately before and after World War II brought significant changes to the Department. The “space race” began, industry was developing new technologies, and the Cold War demanded advanced military systems. Government and business alike turned to universities to help meet these challenges. For the first time, funded research projects sponsored by NASA, the Department of Defense, and private industry became an important focus for the Department.



1940-1970: THE POSTWAR ERA

In 1959, the University of Michigan-Dearborn was established. ME faculty including Raymond Pearson, Axel Marin, Howard Colby and Gordon Van Wylen were instrumental in the creation of the ME program on the new regional campus.

ME faculty were also responsible for establishing the Bioengineering program, with ME professor Glen Edmonson its founding father. The program continues today as Biomedical Engineering.

RESEARCH

The new emphasis on research was seen in both traditional areas and newly emerging technologies. One of the first ME faculty to be heavily involved was Edward Vincent, who won international distinction with Gas Turbines, the first book of its kind. The production engineering group, which included Orlan W. Boston, Robert Caddell, Lester Colwell, Joseph Datsko, William Gilbert, and Kenneth Ludema, carried out world-recognized research on surface roughness measurement and machinability of exotic materials as requested by the War Production Board during World War II.

Other important research included the Orthetics Research Project in the School of Medicine (sponsored by the Department of Vocational Rehabilitation and the National Science Foundation) to develop assistive devices for the upper limbs of disabled persons. ME researchers on this project included Raymond Pearson, Robert Juvinall, Rune Evaldson, and Robert Hess.

Throughout the 1960s, faculty members Wen-Jei Yang, Herman Merte, Vedat Arpaci, and John A. Clark worked on projects that had an impact on the design of NASA’s Saturn launch vehicle.

THE LONG-DURATION EXPOSURE FACILITY (LDEF) (SECTION DIVIDER) HELD SAMPLES FROM PROFESSOR FELBECK.

ME FACULTY DAVE COLE (ABOVE) WORKS WITH STUDENTS IN THE AUTO LAB TEST CELL. COLE IS THE FORMER DIRECTOR OF THE U-M COLLEGE OF ENGINEERING’S OFFICE FOR THE STUDY OF AUTOMOTIVE TRANSPORTATION.

Government-funded research related to nuclear power was carried on in the 1960s. Frederick G. Hammitt's work on cavitation in liquid metal in breeder reactors and Edward Lady's doctoral research on boiling at low head flux were two important examples. And, in another emerging technology, Lester Colwell did pioneering work on numerical control of machines.

In the 1960s, the total contract research conducted in ME labs was estimated at $1.1 million. Faculty publications numbered about 80, including three textbooks.

CURRICULUM

The graduate program expanded in tandem with the Department's research activities. Only 21 PhDs were conferred during the first 70 years of the Department's existence. For the period 1940 to 1970, that number soared to 151.

In 1958, ME got a first taste of the technology that would one day revolutionize engineering education and research, when faculty members attended the Ford Foundation-sponsored Project on the Use of Computers in Engineering Education. They learned about the University's mainframe computer and how it could be used in teaching and research. Faculty began to assign keypunch computer problems in classes.

In 1961, the undergraduate program was completely revamped. Then-chair Gordon Van Wylen described the reorganized curriculum in the 1961 annual report: "A complete reorganization of the undergraduate laboratories has been effected....It is anticipated that this will make the lab work a more significant educational experience for the student and that the theoretical and experimental aspects of engineering will be more effectively related to each other."

FACILITIES

By the early 1950s, it was apparent that the College's old buildings were no longer adequate. In 1956, the Walter E. Lay automotive laboratory was completed, with the state of Michigan providing the $1.85 million construction costs; Michigan industries added an extra $500,000 for equipment, Steelcase donated the furniture and International Nickel Company donated a mobile lab. In 1958-1959, researchers in thermodynamics, heat transfer and fluid mechanics moved to new facilities in the GG Brown Building on North Campus.

In 1953, the Michigan Digital Automatic Computer (MIDAC) was designed and built at the Willow Run Research Center. One of only 20 high-speed electronic digital computers in the country, it was said to be "some 20,000 times faster than a professional mathematician using a desk calculator," (TechniUM + No. 18, June 1980). In 1959, the Board of Regents authorized construction of a new Computing Center on North Campus, with powerful mainframe computers and a terminal system known as the Michigan Terminal System (MTS).

When the Department was established in the late 1800s, engineers prepared for careers in railroads, surveying, shipbuilding or manufacturing. The role of the mechanical engineer has evolved since then, expanding to new industries like automotive engineering, hydraulics, cryogenics, space technology and nuclear power. By the end of the 20th century, the field added the study of lasers, solar energy, automation and control, acoustic emission, composite materials and flexible manufacturing.

MOUNTED ON A CHEVROLET CHASSIS, THE "BLUE BIRD" (ABOVE) SERVED AS ONE OF THE UNIVERSITY'S FIRST TEST VEHICLES. ITS EXOTIC DESIGN HELPED TO DETERMINE AIR RESISTANCE TO MOTION IN LAND VEHICLES, AND TO EXPLORE THE EFFECT OF CHANGES IN VEHICLE SHAPE. IN THE DAYS BEFORE STRAIN GAUGES, LAY SUSPENDED THE SHELL OF THE "BLUE BIRD" ON AN ASSEMBLY OF SCALES TO MEASURE WIND RESISTANCE WHILE DRIVING.

1970-2000

Computers made it possible to explore many problems in traditional research areas that were previously inaccessible. Sponsored research and graduate programs grew rapidly.

OTHER RESEARCH OF THIS PERIOD:

- Samuel Clark (adhesion and reliability of flexible composites)
- Maria Comninou (crack closure and contact at interfaces)
- Deba Dutta (computer-aided design and manufacturing)
- David Felbeck (failure and toughness of engineering materials);
- Julian Frederick (ultrasonic imaging and acoustic emissions);
- Kenneth Ludema (rheology and tribology);
- Christophe Pierre (vibration and wave localization in spatially repetitive structures with imperfections);
- Albert Schultz (biomechanics of mobility impairments in the elderly);
- Richard Scott (optimization of layered composite media vibration and wave propagation in rotating elastic structures);
- Leonard Segel (vehicle dynamics);
- George Springer (structure of rarefied rocket plasma);
- Gretar Tryggvason (bubbles and droplets);
- Wen-Jei Yang (thermal fluid phenomena in biological, anatomical and physical systems);
- Vedat Arpaci (efficient drying versus pulse combusters);
- Michael Chen (thermocapillary flows in welding and crystal growth);
- Herman Merte (forced convection boiling in microgravity);

1970-2000: LEADERSHIP IN HIGH TECHNOLOGY

The first female faculty member, Maria Comninou, joined Applied Mechanics in 1974; the first African American faculty member, Elijah Kannatey-Asibu, Jr., joined ME in 1983; the long-awaited move to North Campus was realized; and the Department gained strength through its merger in 1979 with the Applied Mechanics Department, acquiring the new name Mechanical Engineering and Applied Mechanics (MEAM).

By 2000, the Department was ranked consistently among the top five ME departments by U.S. News & World Report and the National Research Council, and occasionally among the top two or three. Thirteen percent of ME Faculty were now female—the largest percentage of any ME department in the country at the time.

RESEARCH

Total research expenditures climbed from about $500,000 per year in the early 1970s to over $20 million in 2000, enabling steady growth in the doctoral program. This emphasis not only increased engineering knowledge, it also enriched the educational experience of all MEAM students.

The energy crisis of the mid-1970s sparked a search for alternative energy sources, and solar energy was considered one of the most promising. John A. Clark established the Department's Solar Energy Laboratory in 1973, which served as the chief source of technical advice and research for all the solar energy companies in Michigan. Clark later became technical director of Star Pak Energy Systems Company, which developed and marketed the devices conceptualized in the U-M solar lab.

ME PROFESSOR NOBORU KIKUCHI AND STUDENT (SECTION DIVIDER), FROM THE EARLY 70'S USING A COMPUTER FOR ENGINEERING ANALYSIS. KIKUCHI IS A WORLD RENOWNED SCHOLAR IN ADAPTIVE FINITE ELEMENT METHODS INCLUDING AUTOMATIC MESH GENERATION AND REMISING SCHEMES FOR NONLINEAR PROBLEMS IN MECHANICAL ENGINEERING AND APPLIED MECHANICS.

ME made strides in traditional areas as well. In the 1970s, important automotive research was carried out by Donald Patterson, William Mirsky, Jay Bolt and David Cole, including a project to see if thermal reactors could control emissions as well as catalytic converters. The group's research revealed the limitations of thermal reactors, paving the way for universal use of catalytic converters. In 1978, the Office for the Study of Automotive Transportation (OSAT) was founded; OSAT continues today as the nonprofit Center for Automotive Research.

Automotive faculty carried their technology beyond the University and established private companies. Cole, Mirsky and Patterson were among the founders of MI Automotive Research. Later, the group founded QED Environmental Systems to manufacture a pump design they invented for obtaining water samples around dump sites. Departmental depth and technical expertise also led to the establishment of the Automotive Research Center (ARC) in 1994, under the leadership of Panos Papalambros and colleagues, in partnership with the U.S. Army Tank Automotive Research Development and Engineering Center (TARDEC). The emphasis on automotive engineering also led to the creation of other centers including a new $5 million General Motors Satellite Research Laboratory in 1998.

The emerging field of robotics research saw many major and lasting contributions from the research conducted by Yoram Koren and Johann Borenstein. They developed a potential field method for mobile robot navigation, an electromechanical snake robot, an electronic guide cane for the blind and many other robotic technologies. Their mobile robot CARMEL took first place in the 1992 artificial intelligence robotics competition.

Research in manufacturing engineering also flourished. Elijah Kannatey-Asibu used acoustic emission sensing for tool wear and breakage monitoring. Jyoti Mazumder explored laser processing of materials. A Center for Dimensional Measurement was established by Sam Wu with funding from industry and the NSF. Wu, together with his students, Jun Ni and Jack Hu, also established the "2-mm Program" with funding from the National Institute of Standards and Technology and the automotive industry, which had a major impact on the U.S. auto industry. After Wu's untimely death in 1992, the Department hired Ni and Hu; they co-directed the S. M. Wu Manufacturing Research Center, which was named in his honor.

Koren and Galip Ulsoy developed the concept of Reconfigurable Manufacturing Systems, which was crucial to the establishment, in 1996, of the NSF-funded Engineering Research Center (ERC) for Reconfigurable Manufacturing Systems (RMS). With NSF grants, Michigan manufacturers and the state of Michigan, the ERC/RMS would develop RMS-enabled factories capable of readily designing new production systems, sensors, controls and machining equipment. Michigan engineers helped factories respond quickly to market demands, reduce product-development time and expense, offer more choices to consumers and become a driver of economic growth.

FACILITIES

In 1983, the Department completed the move to North Campus that had begun some 30 years earlier.

During the 1970s, computing was performed using time-sharing on MTS. The personal computer revolution came to the College in 1983, with the establishment of the Computer-Aided Engineering Network (CAEN). CAEN operated one of the largest integrated, multi-vendor workstation networks in the academic world. More than 2,000 workstations and microcomputers were distributed in offices and labs; the system was recognized as a model of distributed computing environment for engineering and computer science instruction and research.

The early 1980s also saw ME faculty employ the first laboratory data acquisition and control systems in their research, and the establishment of a laboratory course equipped with PCs for real-time data acquisition, signal processing and control.

CURRICULUM

In the 1980s, ME established itself as a leading department as reflected in its rankings by *U.S. News & World Report* and the National Research Council.

SOLAR CAR MILESTONES

Since 1990 the U-M Solar Car team has won 6 consecutive National Championships, 9 overall, 6 Top-3 World Finishes and 1 International Championship

1988: GM issues a challenge to college students across the country: design and build a solar car to race from Florida to Michigan in Sunrayce '90.

JUNE 1990: A team of U-M students arrived at the starting line with its "Sunrunner" vehicle, which takes 1st place, crosses the finish line with a 90-minute lead over the second-place finisher.

NOVEMBER 1990: Sunrunner competes in the World Solar Challenge in Australia and finished third in the world.

1991: Sunrunner was retired from competition and put on exhibit at the Henry Ford Museum in Dearborn, Michigan.

1993: Sunrayce '93, a new team of Michigan students begins to build Michigan's second solar car, "Maize & Blue," for a 1,000-mile race from Texas to Minneapolis. U-M pulled into the lead on the fifth day and finished in 1st place, again 90 minutes ahead of the second-place car.

2001: M-Pulse wins American Solar Challenge and finishes 3rd in the World Solar Challenge

2005, 2008, 2009, 2012 AND 2014: Momentum, Continuum, Infinium, Quantum, and Quantum II all earn first place finishes in the American Solar Challenge, respectively.

2017: Novum takes home U-M's most successful Bridgestone World Solar Challenge finish yet in a historic second-place win. Novum is the smallest, most aerodynamic Michigan solar car ever.

In the spring of 1992, new chair, Panos Papalambros appointed an undergraduate curriculum review committee to examine the curriculum at other engineering schools and conduct alumni surveys. A year later, the committee presented a preliminary proposal for curriculum revisions. It maintained the strong core in engineering science but put more emphasis on hands-on experience, creative problem-solving and communications and teamwork. Two major changes were implemented: a reorganization of the required laboratories, and the establishment of a sophomore class in design and manufacturing to include computer-aided design and hands-on experience in a machine shop.

The senior project-based design course, ME450, utilized engineering projects form local industry, and became a role model for senior design project courses throughout the College of Engineering.

In addition to benefiting from an enhanced formal curriculum, undergraduate students engaged in many extracurricular activities, with 95+% of all ME undergrads involved in co-ops and summer internships in companies around the world.

The Department also developed the Master of Engineering and Doctor of Engineering professional degree programs, and their delivery by distance learning systems to engineers in industry. The first M. Eng. and D. Eng. Degrees were awarded in manufacturing in 1994. Galip Ulsoy, dounding director of the manufacturing program, developed an agreement with General Motors for its engineers worldwide to enroll in the M. Eng. program via distance learning technologies.

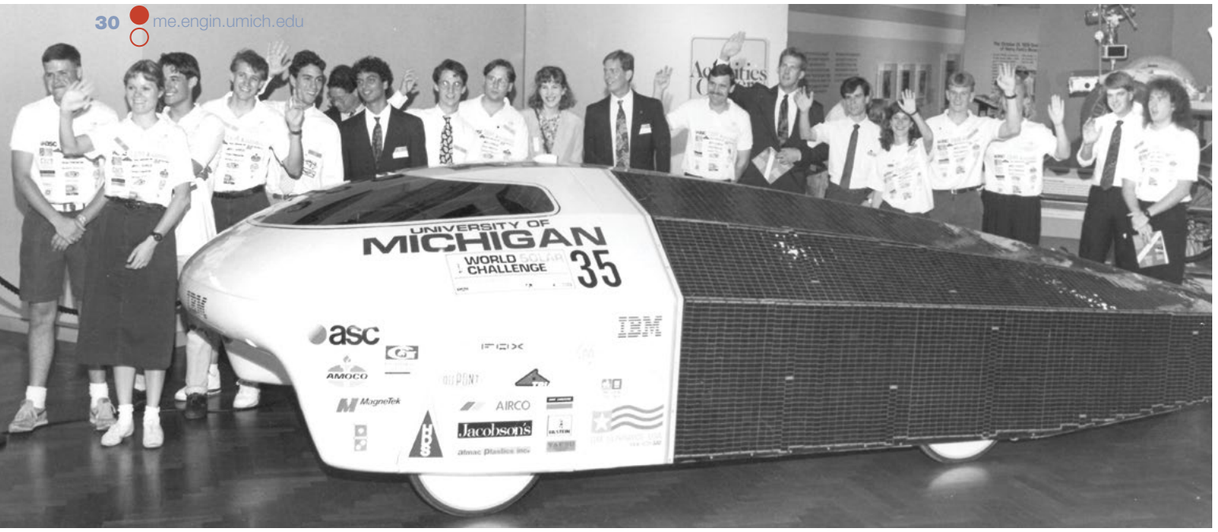
CHIA-SHUN "GUS" YIH AND FLUID MECHANICS

Chia-Shun Yih was the Stephen P. Timoshenko Distinguished University Professor in the Department from 1968 until his retirement in 1988. He was one of the most honored professors in the Department's history and was a member of the U.S. National Academy of Engineering (NAE) and the Academica Sinica in China. His contributions to the literature of fluid mechanics were extensive and important, and his books are classic references for students and researchers in the field.

MILTON CHACE AND MECHANICAL DYNAMICS SOFTWARE SOLUTIONS

As a doctoral student in the 1960s and faculty member in the 1970-80s, Milton Chace conducted pioneering research in computer-aided engineering and mechanical dynamic system analysis, which enabled computerized mechanical simulations that would eliminate the need for expensive prototypes. In 1969, Chace's research team developed a two-dimensional program named DRAM (Dynamic Response of Articulated Machinery), a program that included a computer language that provided automated development of the correct differential equation set for whatever problem was modeled by the user. Later, PhD student Nicholae Orlandea created a prototype three-dimensional computer simulation program, which he named ADAMS (Automated Dynamic Analysis of Mechanical Systems). In 1977—in an early and highly successful example of the increasing sophistication of the Department's involvement in technology transfer—Chace and Michigan Engineering colleagues Mike Korybalski and John Angell formed Mechanical Dynamics, Inc. (MDI).

CHIA-SHUN "GUS" YIH (ABOVE) WAS THE STEPHEN P. TIMOSHENKO DISTINGUISHED UNIVERSITY PROFESSOR IN THE MECHANICAL ENGINEERING AND APPLIED MECHANICS DEPARTMENT FROM 1968 UNTIL HIS RETIREMENT IN 1988. HE IS ONE OF THE MOST HONORED PROFESSORS IN THE DEPARTMENT'S HISTORY.



CHARLES M. VEST: HOLOGRAPHY, TOMOGRAPHY AND ACADEMIC LEADERSHIP

A graduate student in ME, Charles M. Vest stayed on at Michigan and became a faculty member in the Department. Vest's early work on holographic measurement of temperature fields in natural convection (inspired by U-M professor Emmett Leith and his colleagues in Electrical Engineering) led to experiments in computed tomography. In the early 1970s, Vest and his students considered the experimental information generated by multiple beams traversing fluids in various directions and realized that three-dimensional measurements of the density of fluids could be obtained from interferometric measurements. The procedure for obtaining these measurements is similar to that for getting medical images from CT and MRI scanners, and Vest's work led to a powerful imaging method widely used to validate predictions in combustion, aerodynamics and heat transfer. Vest went on to serve as associate dean and dean of COE, then provost of the University. From 2000 to 2014 he was president of the Massachusetts Institute of Technology (MIT). He also served as president of the National Academy of Engineering.

SHIEN-MING "SAM" WU: STATISTICAL METHODS AND MANUFACTURING ENGINEERING

In 1987, Shien-Ming "Sam" Wu joined the Department after 30 years on the faculty of the University of Wisconsin. Wu was the first researcher to introduce advanced statistical techniques to manufacturing research and development, and brought rigor and quantitative methods into manufacturing processes and systems. He created a "game changer" for the manufacturing industry by building the strongest academic/industry collaborative research program in the nation. With funding from the NIST Advanced Technology Program, he created the "2-mm Program." Wu's impact was profound, and his contributions have modernized manufacturing processes of major industries in the U.S. and abroad. His legacy continues with research conducted in the S. M. Wu Manufacturing Research Center, led by his former doctoral student Jun Ni.

ALBERT B. SCHULTZ: SPINAL BIOMECHANICS AND FALLS IN THE ELDERLY

Albert B. Schultz started his career at the University of Illinois in Chicago, moving U-M in the mid-1980s. He was recognized as a leader in whole body biomechanics for his research on spinal mechanics, spinal cord injuries and balance and falls in the elderly. His research explored the assessment, treatment and prevention of physical problems and injuries that commonly arise in older populations. Schultz was among the most honored faculty to serve in the Department. He retired in 1999, but the biomechanics lab he established continues under the leadership of his long-time colleague and collaborator James Ashton-Miller.

In 1999-2000 MEAM once again became the "Department of Mechanical Engineering." This was a clear victory for U-M's science-based engineering education championed by Timoshenko. In fact, the applied mechanics program had so transformed Mechanical Engineering that the distinction between the two was no longer valid.

U-M FIRST SOLAR CAR, SUNRUNNER (ABOVE), RACED IN THE 1990 SUNRAYCE, WON THE EVENT AND WENT ON TO PLACE THIRD IN THE 1990 WORLD SOLAR CHALLENGE. SUNRUNNER IS ON DISPLAY AT THE HENRY FORD IN DEARBORN, MICHIGAN.

ERC: BRINGING RMS SCIENCE TO THE FACTORY FLOOR

Founded by Yoram Koren in 1996, the Engineering Research Center for Reconfigurable Manufacturing Systems (ERC/RMS) helps develop new scientific methodologies and innovative equipment that enable companies to launch production faster, with higher productivity and improved parts quality. RMS technologies give manufacturers the production capabilities they need when they need it—an important advantage in the global marketplace.

Once again, ME was faced with the challenge of redefining itself. Mechanical engineers were needed to address new problems like micro-electro-mechanical systems (MEMS), nanomanufacturing, robotic rehabilitation and biomechanics at the cellular and molecular level.

2000-2018: 21ST CENTURY REDEFINED

As a means to address the rapid changes occurring in the early 2000s, ME chair Galip Ulsoy joined forces with mechanical engineering department heads in the Big Ten Plus Group, which had submitted a proposal to NSF to hold a workshop in January 2002 entitled “Redefining Mechanical Engineering.” The workshop addressed the discipline’s evolving nature and attempted to redefine the field by focusing on how current trends were likely to affect the future of mechanical engineering research and education. Ulsoy and the next ME chairs Dennis Assanis and Kon-Well Wang used this as a blueprint to grow the Department into emerging areas.

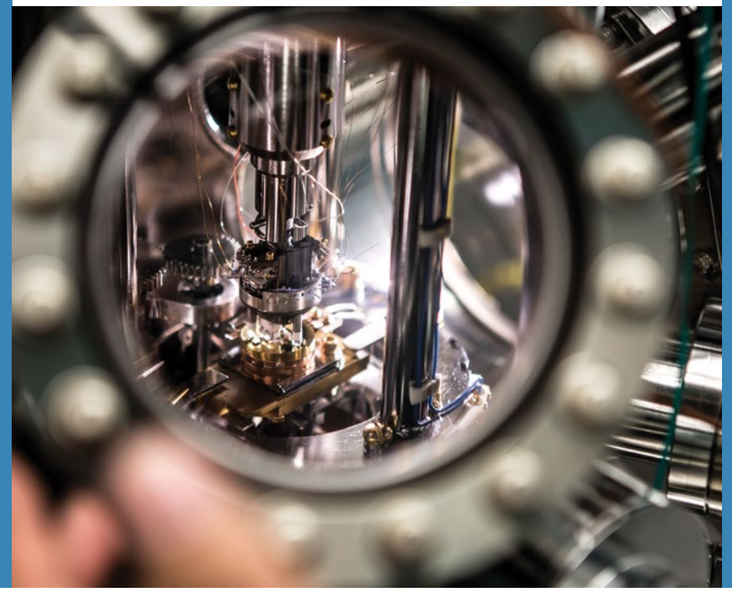
Later events, under the leadership of ME chair Kon-Well Wang, continued the national discussion. As a member and chair of the ASME Department Heads Executive Committee, Wang developed agenda items at ASME’s Department Heads Forum and its International Mechanical Engineering Education Leadership Summit, which kicked off several new initiatives among ME chairs nationwide. Wang also encouraged U-M ME colleagues to serve as panelists and speakers: Sridhar Kota spoke about how to drive a national agenda at the White House Office of Science and Technology Policy; Diann Brei described U-M’s ME curriculum flexibility enhancement and RISE program; Noel Perkins addressed U-M’s major facility renovation for design/manufacturing education; and Steve Skerlos spoke about sustainable manufacturing). These engagements provided the Department with a platform to more significantly impact the academic community.

In 2010, under chair Kon-Well Wang, a strategic plan was developed. Annual faculty retreats were held to follow up on strategic action items. Goals included undergraduate and graduate education, faculty and staff development, facilities and space and a research and hiring focus on: (1) bio- and health systems, (2) emerging manufacturing, (3) energy and environment and (4) future transportation.

PROFESSOR YORAM KOREN (SECTION DIVIDER), DIRECTOR OF THE ENGINEERING RESEARCH CENTER FOR RECONFIGURABLE MANUFACTURING SYSTEMS AT U-M, INSPECTS THE INDEXING MECHANISM OF THE NEW ‘ARCH-TYPE’ RECONFIGURABLE MACHINE TOOL IN THE ERC/RMS TESTBED.

MILESTONES

- In 2008, College of Engineering departments began handling their own development activities.
- ME Chair Kon-Well Wang has worked closely with the College Advancement Office to raise funds for ME's strategic needs.
- $15 million in private funds and $30 million from the state of Michigan were raised to fund the GG Brown addition and other major renovation projects.
- Tim Manganello, chief executive officer of Borg Warner, Inc., and the BorgWarner Foundation endowed ME's chair with a $2 million gift. The first endowed department chair in the College, the gift enabled new departmental initiatives to achieve planned strategic goals.
- ME has now created a comprehensive 9,000 person database to help enhance communication with alumni.



RESEARCH

Extensive cutting-edge research led to commercialization efforts by ME faculty:

- Jyoti Mazumder established POM Group Inc. (now DM3D Technology LLC) to develop laser direct metal deposition machines
- Noel Perkins developed an ultra-small MEMS-based inertial measurement unit, which served as the basis of commercialization efforts in fly fishing (Castanalysis LLC).
- Steve Skerlos' research in cutting fluids led to two startups: Accuri Cytometers and Fusion Coolant Systems.
- Shorya Awtar's innovations in laparoscopic and minimally invasive instruments helped established FlexDex Surgical.
- Sridhar Kota's research in compliant mechanisms via his company, FlexSys, Inc. in collaboration with the U.S. Air Force and NASA created a revolutionary shape-changing aircraft wing.
- Karl Grosh's research led to the creation of Vesper Technology, which uses piezoelectric materials to create the most advanced Micro Electro-Mechanical (MEMS) microphones on the market.
- Shorya Awtar comes out with U-M ME's startup FlexDex Surgical's first product, a simple, ergonomic and intuitive "needle driver" for stitching inside the body. It has since been used all over the world in operations.

During this period, the number of tenure track faculty grew from about 50 to 72. New faculty brought expertise in emerging areas, such as the science, design and manufacturing of micro- and nanoscale devices; biomechanics at the cellular and molecular levels; connected and automated vehicles; rehabilitation robotics; and energy storage materials. Under the leadership of successive associate chairs for graduate education—Karl Grosh, Steve Skerlos and Kevin Pipe—the ME PhD qualifying exams were redesigned and further enhanced.

Throughout its history, the Department has taken full advantage of its southeastern Michigan location and has excelled in automotive and manufacturing engineering. Close ties to engineers working in related industries were developed, and many students have conducted research and undertaken projects in special facilities in nearby industries.

The TARDEC-funded Automotive Research Center (ARC) expanded its operation under the leadership of Dennis Assanis and Anna Stefanopoulou. Automotive saw an increasing emphasis on control systems to reduce emissions, improve fuel economy and enhance safety, and engineers focused on new technologies such as electric vehicles, hybrid vehicles and batteries and connected vehicles. The Department's leadership in manufacturing continued in close partnership with industry, and continues today with emphases on sensing, diagnostics and manufacturing automation and micro- and nano-manufacturing.

A number of ME faculty took scholarly leaves to become involved in national policy through service to various government organizations. Ulsoy served as director of the Division of Civil and Mechanical Systems at NSF. Kota was assistant director for advanced manufacturing at the White House Office of Science and Technology Policy, and played a key role in launching the National Advanced Manufacturing Partnership and the Manufacturing Innovation Institutes. Albert Shih was Assistant Director for Technology at the NIST Advanced Manufacturing National Program Office of the National Institute of Standards and Technology (NIST). And in 2017, Dawn Tilbury was selected to serve as an NSF Assistant Director and lead the Directorate for Engineering.

The Department of Mechanical Engineering continues to be near the top of *U.S. News & World Report*'s annual rankings, as well as among the top 5 in the world by QS-World Universities.

RESEARCH AND EDUCATION

Research funding increased from about $20 million/year in 2000 to more than $35 million/year in 2015. Much of the increase has been associated with major research centers, including ARC, ERC/RMS, S. M. Wu Manufacturing Research Center and CLAIM, and new centers in advanced battery systems, robotics, clean energy, lightweight materials and socially engaged design. The Ground Robotics Reliability Center (GRRC) was established in 2007 with support from the U.S. Army TARDEC, with a focus on the reliability of unmanned ground vehicles.

Under the leadership of Steve Ceccio, the Naval Engineering Education Center was launched in 2009, to educate the next generation of naval systems engineers. A Department of Energy U.S.-China Clean Energy Research Center was established in 2010 under the leadership of Dennis Assanis; it continues under the directorship of Huei Peng. The Clean Vehicle Consortium focuses on disruptive technologies to improve fuel efficiency in vehicles. Another major center, established in 2014, is the American Lightweight Materials and Manufacturing Innovation Institute (ALMMII) under the leadership of Alan Taub.

ME established the Findley Learning Center (endowed by the family of former ME faculty member William M. Findley) as a dedicated space for student-instructor interaction. It has been so popular with students (who can find assistance with homework and exam preparation at the center virtually any time of the day) that it has now been adopted by other departments and is being expanded as part of renovations in GG Brown.

In 2000, the Department instituted the ME Graduate Symposium, where grad students can present their research in a relaxed environment. The symposium was expanded to include best presentation awards and poster sessions and became so popular it continues today as a College-wide event held every fall.

Under the leadership of Diann Brei, ME's associate chair for undergraduate education (2012-17), new initiatives were carried out to realize the vision of redefining mechanical engineering following the outcomes of the national 5xME workshops. ME's undergraduate curriculum has been revised to improve flexibility for students to explore disciplines outside engineering.

One of the additions to the curriculum was ME's Research, Innovation, Service and Entrepreneurship (RISE) program, which allows undergraduate students the opportunity to work alongside world-renowned faculty in state-of-the-art facilities on real-world projects that impact our society and future. The projects from the RISE program are then showcased in MEUS, the ME Undergraduate Symposium held at the end of each term.

Significant resources were also allocated to support undergraduate education in emerging new fields. For example, ME has embedded mechatronics into our Design and Manufacturing core curriculum, and nanoscale concepts were embedded in the senior lab core course (ME495) via leveraging upon atomic force microscope technology, introducing undergraduates to nanoscale phenomena in mechanics, biomechanics and heat transfer.

The Department began various international partnerships to provide global experiences for its students. In 2000, ME formed a strategic partnership with Shanghai Jiao Tong University (SJTU) to help reshape the way Chinese engineering colleges educated their students. SJTU used an ME model to restructure its undergraduate curriculum, and a pilot class of 60 students was admitted into the new program that same year as ME faculty members began their first set of lectures at SJTU. This effort, under the leadership of Jun Ni, has developed into one of the most successful international academic collaborations in the world and has resulted in the establishment of the UM-SJTU Joint Institute, with Jun Ni as its first dean.

In February 2001, ME signed a memorandum of understanding for a collaborative program with the mechanical engineering department of the Korean Advanced Institute of Science and Technology (KAIST). The agreement created a formal relationship between the two schools that included a plan to exchange students and faculty members for research and academic purposes of common interest.

Extracurricular activities continued to play a major role at ME, with nearly every student involved in project teams, industry internships or co-op experiences. The Better Living Using Engineering laboratory (BLUElab) provides engineering-based sustainability-related service opportunities for ME students. BLUElab activities include water accessibility, solar technology, resource management in homes, anaerobic digestion, engineering education and wind-powered technology. Each project team works with a partner community in Ann Arbor or Mexico, El Salvador, Guatemala, Jamaica, India or Nicaragua.

The Laboratory for Innovation in Global Health Technology (LIGHT) uses design ethnography techniques to co-creatively design and assess cost-effective technology solutions to healthcare challenges in low-income countries such as Ghana, Ethiopia and China.

And ME students and alumni helped bring the U-M solar car M-Pulse to victory in 2001 at the American Solar Challenge. M-Pulse was the third Wolverine winner (in addition to Sunrunner in 1990 and Maize & Blue in 1993) of six American Solar Challenge races. This success continued with first-place finishes by Momentum (2005), Continuum (2008), Infinium (2009), Quantum (2011) and Quantum II (2014) and placing 2nd in the world in the 2017 Bridgestone World Solar Challenge in Australia with their smallest car to date, Novum, giving ME nine national championships, six Top-3 World finishes and one International Championship.

FACILITIES

To meet the needs of the “new ME” in teaching and research, major improvements to the Department’s facilities were needed. This was advocated by several ME chairs (Papalambros, Ulsoy, Assanis, and Wang). From 2008 to 2017, three major facility projects were undertaken, planned, designed and constructed under the leadership of chair Kon-Well Wang and associate chairs Dawn Tilbury and Noel Perkins.

A new 62,880-square-foot world-class research complex, completed in 2014, with special facilities to support emerging areas. This $46-million addition to the GG Brown building was partially supported by a $9.5-million grant from NIST. At the core of the building, and resting on a separate and isolated foundation, lies an ultra-low vibration laboratory, which includes eight separate testing chambers with stringent control of vibration, temperature and humidity.

A separate renovation project costing $50 million, with $30 million from the state of Michigan, was launched upon the completion of the GG Brown addition in summer 2014. It improves the infrastructure of the building enormously, and, in addition, realizes a vision of a student-centric environment for teaching, learning and advising. The newly renovated space integrated many facilities in the central hub, including a large auditorium-style classroom, an advisee-friendly advising center, a modernized learning center for student-faculty interaction and expanded laboratory spaces for all the required Design & Manufacturing courses and instrumentation lab courses that support the “Design, Build, Test” pedagogical paradigm. The renovation project was completed in summer of 2016.

In 2017 an interior, as well as test cell retooling renovation of the Walter E. Lay Automotive Lab was completed. The project provided a much needed facelift to the interior of the Auto Lab, including updated offices, corridors and staircases, improved lighting and display areas, a new lounge and conference rooms, updated restrooms and an added lactation room, and HVAC and electrical upgrades.

Another U-M facility with a strong connection with ME is Mcity, part of the Mobility Transformation Center (MTC). MTC, launched in 2013, is a partnership between U-M, the U.S. and Michigan Department of Transportation to dramatically improve the safety, sustainability and accessibility of the ways that people and goods move. The current director of the MTC is ME faculty Huei Peng. In 2016, Mcity, an MTC offspring, was launched. Mcity is a one-of-a-kind test site for connected and automated vehicles located at U-M's North Campus Research Complex. The test site has over 3,000 connected vehicles in Ann Arbor as well as instrumentation installed at most major intersections, used to collect traffic data. Mcity is the world's first connected and automated vehicle proving grounds, and will provide a unique resource for not only data collection, but for evaluation of vehicle connectivity and automation technologies in a controlled but realistic environment.

NATIONAL ACADEMY OF ENGINEERING AND DISTINGUISHED UNIVERSITY PROFESSORSHIPS

Seven ME core faculty members were inducted into the National Academy of Engineering (NAE): Yoram Koren, Galip Ulsoy, Dennis Assanis, Jyoti Mazumder, Jack Hu, Ellen Arruda and Noboru Kikuchi. Election to the NAE is among the highest professional distinctions accorded to an engineer. Three ME professors were recognized with Distinguished University Professorships, one of U-M's top honors: Galip Ulsoy, Yoram Koren and Panos Papalambros.

YORAM KOREN: A LEADER IN MANUFACTURING AUTOMATION

In 1980, Yoram Koren joined the Department as the Paul Goebel Visiting Professor, from the Technion in Haifa, Israel. He stayed until his retirement in 2014 as the James J. Duderstadt Distinguished University Professor of Manufacturing. Koren made many important contributions, including the first adaptively controlled machine tool, cross-coupled controllers for contouring and state modeling of tool wear and a virtual field methodology for obstacle avoidance in mobile robots. Most importantly, he is widely recognized as the founder of reconfigurable manufacturing systems (RMS). Koren was the director of the NSF-sponsored Engineering Research Center (ERC)/RMS, the first ERC at U-M and a massive research effort involving dozens of companies, dozens of faculty and hundreds of students. Koren's vision was to make manufacturing responsive to the changing needs of the consumer. Many of the technologies developed by the Engineering Research Center (ERC)/RMS researchers are in use in manufacturing plants around the world. Koren is among the most honored faculty in the history of the Department, winning numerous national and international awards, including election to the NAE and a Distinguished University Professorship.

MECHANICAL ENGINEERING TIMELINE AND DEPARTMENT CHAIRS – THROUGH THE YEARS (1868 –)

MECHANICAL ENGINEERING
UNIVERSITY OF MICHIGAN

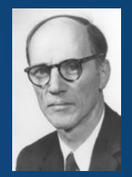
Mortimer E. Cooley
1881-1904

Henry Anderson
1917-1937

Ransom Hawley
1940-1951

Wyeth Allen
1955-1956

Arthur Hansen
1965-1966



J. Raymond Pearson
1974-1978

Richard Sonntag
1981-1992

A. Galip Ulsoy
1998-2001

Kon-Well Wang
2008-2018

1900

1910

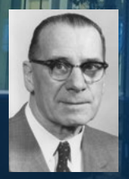
John Allen
1904-1917

1920

1930

John Emswiler
1937-1940

1940



Edward Vincent
1951-1955

1950

Gordan Van Wylen
1956-1965

1960

John Clark
1966-1974

1970

1980

David Pratt
1978-1981

1990

Panos Papalambros
1992-1998

2000

Dennis Assanis
2001-2007

2010

Ellen Arruda
2018-

2020

NAE RECIPIENTS

Election to the National Academy of Engineering (NAE) is among the highest professional distinctions accorded to an engineer.

Chia-Shun Yih	1980
Albert Schultz	1993
Ronald Larsen	2003
Yoram Koren	2004
Steven Goldstein	2005
Alan Taub	2006
Galip Ulsoy	2006
Dennis Assanis	2008
Jyoti Mazumder	2012
Jack Hu	2016
Ellen Arruda	2017
Noboru Kikuchi	2017

NOBORU KIKUCHI: HOMOGENIZATION AND TOPOLOGY OPTIMIZATION

Noboru Kikuchi, the Roger L. McCarthy Professor of Mechanical Engineering, is an expert in computational mechanics, including the finite element method (FEM). He joined the Department in 1980 and worked on a variety of important research topics, including computational methods for contact problems, for adaptive mesh generation in FEM, and the homogenization method. That method, developed with Martin Bendsoe of the Technical University of Denmark, enabled not just the optimization of the dimensions of a given mechanical design, but the determination of the optimal topology itself from the loading and material properties. This field of topology optimization has had profound impact on the design of complex mechanical structures. Kikuchi collaborated with many colleagues, such as Sridhar Kota on design of compliant mechanisms, Panos Papalambros and Deba Dutta on rapid design and fabrication of parts designed using homogenization, and Jyoti Mazumder on additive manufacturing. Kikuchi's work is widely used in industry. He retired from the Department in 2015 and became president of the Central Research and Development Labs at Toyota Motor Company. He was elected to NAE in 2017.

U-M ME DOCTORAL STUDENTS (ABOVE FROM LEFT), WILL LEPAGE AND KAITLYN MALLETT, U-M TIM MAGANELLO/BORGWARNER DEPARTMENT CHAIR OF MECHANICAL ENGINEERING KON-WELL WANG, U-M ROBERT J. VLASIC DEAN OF ENGINEERING DAVID C. MUNSON, JR., STATE OF MICHIGAN GOVERNOR RICHARD D. SNYDER, U-M PRESIDENT MARK S. SCHLOSSER, AND NIST PROGRAM COORDINATION OFFICE DIRECTOR DR. JASON BOEHM AT THE DEDICATION OF THE NEW ME FACILITIES, OCTOBER 10, 2014.

A GIANT RUBIK'S CUBE (RIGHT) DESIGNED AND BUILT BY ME STUDENTS AND INSTALLED ON NORTH CAMPUS IS BELIEVED TO BE ONE OF THE WORLD'S LARGEST HAND-SOLVABLE, STATIONARY VERSIONS OF THE FAMOUS PUZZLE. THE 1,500-POUND, MOSTLY ALUMINUM APPARATUS WAS UNVEILED APRIL 14, 2017 ON THE SOUTHWEST CORNER OF THE SECOND FLOOR OF THE GG BROWN BUILDING.