2019-2020 Undergraduate Catalog

Carnegie Mellon University is accredited by the Middle States Commission on Higher Education. The university is authorized to operate in several states. www.cmu.edu

Carnegie Mellon University's Undergraduate Catalog is an annual publication that details academic programs and degrees offered, course descriptions, and university policies and services.

While information in this catalog is current as of August 2019, it is subject to change throughout the academic year. Students should consult with their academic department for the most up-to-date information about program requirements. Members of the campus community may direct catalog changes or inquiries to catalog@andrew.cmu.edu. The next catalog will be published in August 2020; in the interim, new courses will be displayed in the Schedule of Classes (https://enr-apps.as.cmu.edu/open/SOC/SOCServlet), which is published in November and April each year.

Policy Statement
Carnegie Mellon University does not discriminate in admission, employment, or administration of its programs or activities on the basis of race, color, national origin, sex, handicap or disability, age, sexual orientation, gender identity, religion, creed, ancestry, belief, veteran status, or genetic information. Furthermore, Carnegie Mellon University does not discriminate and is required not to discriminate in violation of federal, state, or local laws or executive orders.

Inquiries concerning the application of and compliance with this statement should be directed to the university ombudsman, Carnegie Mellon University, 5000 Forbes Avenue, Pittsburgh, PA 15213, telephone 412-268-1018.


Contents

- Degrees Offered (http://coursecatalog.web.cmu.edu/degreesoffered)
- Schools/Colleges (http://coursecatalog.web.cmu.edu/schools-colleges)
  - College of Engineering (http://coursecatalog.web.cmu.edu/schools-colleges/collegeofengineering)
  - CIT Interdisciplinary Courses (http://coursecatalog.web.cmu.edu/schools-colleges/collegeofengineering/courses)
- Department of Biomedical Engineering (http://coursecatalog.web.cmu.edu/schools-colleges/collegeofengineering/departmentofbiomedicalengineering)
- Department of Chemical Engineering (http://coursecatalog.web.cmu.edu/schools-colleges/collegeofengineering/departmentofchemicalengineering)
- Department of Civil and Environmental Engineering (http://coursecatalog.web.cmu.edu/schools-colleges/collegeofengineering/departmentofcivilandenvironmentalengineering)
- Department of Electrical and Computer Engineering (http://coursecatalog.web.cmu.edu/schools-colleges/collegeofengineering/departmentofelectricalandcomputerengineering)
- Department of Engineering and Public Policy (http://coursecatalog.web.cmu.edu/schools-colleges/collegeofengineering/departmentofengineeringandpublicpolicy)
- Department of Materials Science and Engineering (http://coursecatalog.web.cmu.edu/schools-colleges/collegeofengineering/materialsscienceandengineering)
- Department of Mechanical Engineering (http://coursecatalog.web.cmu.edu/schools-colleges/collegeofengineering/departmentofmechanicalengineering)
- Engineering Minors for Non-Engineering Students (http://coursecatalog.web.cmu.edu/schools-colleges/collegeofengineering/minorsformonengineeringstudents)
- Undergraduate Designated Minors in the College of Engineering (http://coursecatalog.web.cmu.edu/schools-colleges/collegeofengineering/undergraduatedesignatedminors)
- College of Fine Arts (http://coursecatalog.web.cmu.edu/schools-colleges/collageoffinearts)
  - College of Fine Arts Interdisciplinary Courses (http://coursecatalog.web.cmu.edu/schools-colleges/collageoffinearts/courses)
  - Minors Offered by the College of Fine Arts (http://coursecatalog.web.cmu.edu/schools-colleges/collageoffinearts/minors)
- School of Architecture (http://coursecatalog.web.cmu.edu/schools-colleges/schoolofarchitecture)
- School of Art (http://coursecatalog.web.cmu.edu/schools-colleges/schoolofart)
- School of Drama (http://coursecatalog.web.cmu.edu/schools-colleges/schoolofdrama)
- School of Music (http://coursecatalog.web.cmu.edu/schools-colleges/schoolofmusic)

- Dietrich College of Humanities and Social Sciences (http://coursecatalog.web.cmu.edu/schools-colleges/dietrichcollegeofhumanitiesandsocialsciences)
- Undergraduate Economics Program (http://coursecatalog.web.cmu.edu/schools-colleges/undergraudeeconomicsprogram)
- Department of English (http://coursecatalog.web.cmu.edu/schools-colleges/departmentofenglish)
- Department of History (http://coursecatalog.web.cmu.edu/schools-colleges/departmentofhistory)
- The Major in Information Systems (http://coursecatalog.web.cmu.edu/schools-colleges/departmentofinformationsystems)

- Institute for Politics and Strategy (http://coursecatalog.web.cmu.edu/schools-colleges/instituteforpoliticsandstrategy)

- Undergraduate Academic Regulations (http://coursecatalog.web.cmu.edu/aboutcmu/undergraduateacademicregulations)
- Undergraduate Options (http://coursecatalog.web.cmu.edu/aboutcmu/undergraduateoptions)

- Undergraduate Academic Regulations (http://coursecatalog.web.cmu.edu/aboutcmu/undergraduateacademicregulations)
- University Policies (http://coursecatalog.web.cmu.edu/aboutcmu/universitypolicies)
- University Services (http://coursecatalog.web.cmu.edu/aboutcmu/universityservices)
- Department of Athletics and Physical Education (http://coursecatalog.web.cmu.edu/aboutcmu/departmentofathleticsandphysicaleducation)
  - Department of Athletics and Physical Education Courses (http://coursecatalog.web.cmu.edu/aboutcmu/departmentofathleticsandphysicaleducation/courses)
- Reserve Officers' Training Corps (ROTC) (http://coursecatalog.web.cmu.edu/aboutcmu/rotc/courses)
- ROTC Courses (http://coursecatalog.web.cmu.edu/aboutcmu/rotc/courses)

- About CMU (http://coursecatalog.web.cmu.edu/aboutcmu)
- Look at Carnegie Mellon (http://coursecatalog.web.cmu.edu/aboutcmu/lookatcarnegiemellon)
- Undergraduate Admission (http://coursecatalog.web.cmu.edu/aboutcmu/undergraduateadmission)
- Cost of Attendance (http://coursecatalog.web.cmu.edu/aboutcmu/costofattendance)
- Division of Enrollment Services (http://coursecatalog.web.cmu.edu/aboutcmu/enrollmentservices)
- Division of Student Affairs (http://coursecatalog.web.cmu.edu/aboutcmu/divisionofstudentaffairs)
- Undergraduate Options (http://coursecatalog.web.cmu.edu/aboutcmu/undergraduateoptions)
- Undergraduate Academic Regulations (http://coursecatalog.web.cmu.edu/aboutcmu/undergraduateacademicregulations)
- University Policies (http://coursecatalog.web.cmu.edu/aboutcmu/universitypolicies)
- University Services (http://coursecatalog.web.cmu.edu/aboutcmu/universityservices)
- Department of Athletics and Physical Education (http://coursecatalog.web.cmu.edu/aboutcmu/departmentofathleticsandphysicaleducation)
  - Department of Athletics and Physical Education Courses (http://coursecatalog.web.cmu.edu/aboutcmu/departmentofathleticsandphysicaleducation/courses)
- Reserve Officers' Training Corps (ROTC) (http://coursecatalog.web.cmu.edu/aboutcmu/rotc/courses)
- ROTC Courses (http://coursecatalog.web.cmu.edu/aboutcmu/rotc/courses)

- About CMU (http://coursecatalog.web.cmu.edu/aboutcmu)
- Look at Carnegie Mellon (http://coursecatalog.web.cmu.edu/aboutcmu/lookatcarnegiemellon)
- Undergraduate Admission (http://coursecatalog.web.cmu.edu/aboutcmu/undergraduateadmission)
- Cost of Attendance (http://coursecatalog.web.cmu.edu/aboutcmu/costofattendance)
- Division of Enrollment Services (http://coursecatalog.web.cmu.edu/aboutcmu/enrollmentservices)
- Division of Student Affairs (http://coursecatalog.web.cmu.edu/aboutcmu/divisionofstudentaffairs)
- Undergraduate Options (http://coursecatalog.web.cmu.edu/aboutcmu/undergraduateoptions)
- Undergraduate Academic Regulations (http://coursecatalog.web.cmu.edu/aboutcmu/undergraduateacademicregulations)
- University Policies (http://coursecatalog.web.cmu.edu/aboutcmu/universitypolicies)
- University Services (http://coursecatalog.web.cmu.edu/aboutcmu/universityservices)
- Department of Athletics and Physical Education (http://coursecatalog.web.cmu.edu/aboutcmu/departmentofathleticsandphysicaleducation)
  - Department of Athletics and Physical Education Courses (http://coursecatalog.web.cmu.edu/aboutcmu/departmentofathleticsandphysicaleducation/courses)
- Reserve Officers' Training Corps (ROTC) (http://coursecatalog.web.cmu.edu/aboutcmu/rotc/courses)
- ROTC Courses (http://coursecatalog.web.cmu.edu/aboutcmu/rotc/courses)

- About CMU (http://coursecatalog.web.cmu.edu/aboutcmu)
- Look at Carnegie Mellon (http://coursecatalog.web.cmu.edu/aboutcmu/lookatcarnegiemellon)
- Undergraduate Admission (http://coursecatalog.web.cmu.edu/aboutcmu/undergraduateadmission)
- Cost of Attendance (http://coursecatalog.web.cmu.edu/aboutcmu/costofattendance)
- Division of Enrollment Services (http://coursecatalog.web.cmu.edu/aboutcmu/enrollmentservices)
- Division of Student Affairs (http://coursecatalog.web.cmu.edu/aboutcmu/divisionofstudentaffairs)
- Undergraduate Options (http://coursecatalog.web.cmu.edu/aboutcmu/undergraduateoptions)
- Undergraduate Academic Regulations (http://coursecatalog.web.cmu.edu/aboutcmu/undergraduateacademicregulations)
- University Policies (http://coursecatalog.web.cmu.edu/aboutcmu/universitypolicies)
- University Services (http://coursecatalog.web.cmu.edu/aboutcmu/universityservices)
- Department of Athletics and Physical Education (http://coursecatalog.web.cmu.edu/aboutcmu/departmentofathleticsandphysicaleducation)
  - Department of Athletics and Physical Education Courses (http://coursecatalog.web.cmu.edu/aboutcmu/departmentofathleticsandphysicaleducation/courses)
- Reserve Officers' Training Corps (ROTC) (http://coursecatalog.web.cmu.edu/aboutcmu/rotc/courses)
- ROTC Courses (http://coursecatalog.web.cmu.edu/aboutcmu/rotc/courses)
dietschcollegeofhumanitiesandsocialsciences/instituteofpoliticsandstrategy

- Department of Modern Languages (http://coursedescriptions.cmu.edu/schools-colleges/dietschcollegeofhumanitiesandsocialsciences/departments/modernlanguages)
- Department of Philosophy (http://coursedescriptions.cmu.edu/schools-colleges/dietschcollegeofhumanitiesandsocialsciences/departmentofphilosophy)
- Department of Psychology (http://coursedescriptions.cmu.edu/schools-colleges/dietschcollegeofhumanitiesandsocialsciences/departmentofpsychology)
- Department of Social and Decision Sciences (http://coursedescriptions.cmu.edu/schools-colleges/dietschcollegeofhumanitiesandsocialsciences/departmentofsocialanddecisionsciences)
- Department of Statistics and Data Science (http://coursedescriptions.cmu.edu/schools-colleges/dietschcollegeofhumanitiesandsocialsciences/departmentofstatistics)
- Dietrich College Interdisciplinary Majors (http://coursedescriptions.cmu.edu/schools-colleges/dietschcollegeofhumanitiesandsocialsciences/interdepartmentalmajors)
- Dietrich College Interdisciplinary Minors (http://coursedescriptions.cmu.edu/schools-colleges/dietschcollegeofhumanitiesandsocialsciences/interdepartmentalminors)
- Dietrich College Interdisciplinary Courses (http://coursedescriptions.cmu.edu/schools-colleges/dietschcollegeofhumanitiesandsocialsciences/courses)
- Heinz College of Information Systems and Public Policy (http://coursedescriptions.cmu.edu/schools-colleges/heinzcollegeofinformationssystemsandpublicpolicy)
- Mellon College of Science (http://coursedescriptions.cmu.edu/schools-colleges/melloncollegescience)
  - Department of Biological Sciences (http://coursedescriptions.cmu.edu/schools-colleges/melloncollegescience/departments/biologicalsciences)
  - Department of Chemistry (http://coursedescriptions.cmu.edu/schools-colleges/melloncollegescience/departments/chemistry)
  - Department of Mathematical Sciences (http://coursedescriptions.cmu.edu/schools-colleges/melloncollegescience/departments/mathematicalsciences)
  - Department of Physics (http://coursedescriptions.cmu.edu/schools-colleges/melloncollegescience/departments/physics)
  - MCS Interdisciplinary Courses (http://coursedescriptions.cmu.edu/schools-colleges/melloncollegescience/courses)
  - Minors Offered by the Mellon College of Science (http://coursedescriptions.cmu.edu/schools-colleges/melloncollegescience/melloncollegescience/minors)
- School of Computer Science (http://coursedescriptions.cmu.edu/schools-colleges/computer)
  - Artificial Intelligence Program (http://coursedescriptions.cmu.edu/schools-colleges/computer/artificialintelligence)
  - Computational Biology Program (http://coursedescriptions.cmu.edu/schools-colleges/computer/undergraduatecomputationalbiology)
  - Computer Science Program (http://coursedescriptions.cmu.edu/schools-colleges/computer/undergraduatecomputerscience)
  - SCS Additional Majors and Minors (http://coursedescriptions.cmu.edu/schools-colleges/interdepartmentalmajorsandminors)
  - SCS Concentrations (http://coursedescriptions.cmu.edu/schools-colleges/interdepartmentalmajorsandminors/interdepartmentalmajorsandminors)
  - SCS Courses (http://coursedescriptions.cmu.edu/schools-colleges/computer/scscomputer)
- Tepper School of Business (http://coursedescriptions.cmu.edu/schools-colleges/tepper)
  - Undergraduate Business Administration Program (http://coursedescriptions.cmu.edu/schools-colleges/tepper/undergraduatebusinessadministrationprogram)
  - Undergraduate Economics Program (http://coursedescriptions.cmu.edu/schools-colleges/tepper/undergraduateeconomicsprogram)

- Carnegie Mellon University in Qatar (http://coursedescriptions.cmu.edu/schools-colleges/qatar)
- Interdisciplinary Programs (http://coursedescriptions.cmu.edu/interdepartmentalmajorsandminors/interdepartmentalmajorsandminors)
  - BXA Intercollege Degree Programs (http://coursedescriptions.cmu.edu/schools-colleges/interdepartmentalmajorsandminors/bxa)
  - BXA Intercollege Program Courses (http://coursedescriptions.cmu.edu/schools-colleges/interdepartmentalmajorsandminors/interdepartmentalmajorsandminors)
- Carnegie Mellon University-Wide Studies Courses (http://coursedescriptions.cmu.edu/schools-colleges/interdepartmentalmajorsandminors/interdepartmentalmajorsandminors)
- Course Descriptions (http://coursedescriptions.cmu.edu/)
- Course Search (http://coursedescriptions.cmu.edu/course-search)
  - /course-search/api (http://coursedescriptions.cmu.edu/course-search/api)
  - /course-search/build (http://coursedescriptions.cmu.edu/course-search/build)
    - /course-search/build/crit.html (http://coursedescriptions.cmu.edu/course-search/build/crit.html)
    - /course-search/build/detail.html (http://coursedescriptions.cmu.edu/course-search/build/detail.html)
    - /course-search/build/settings.html (http://coursedescriptions.cmu.edu/course-search/build/settings.html)

Administration

FARNAM JAHANIAN, President
JAMES H. GARRETT, JR., Provost and Chief Academic Officer
ANGELA BLANTON, Vice President, Finance and Chief Financial Officer
GINA CASALEGNO, Vice President for Student Affairs and Dean of Students
MARY JO DIVELY, Vice President and General Counsel
CHARLES H. KENNEDY, Chief Investment Officer
CATHY LIGHT, Secretary of the Corporation and Advisor to the President
RODNEY MCCLENDON, Vice President, Operations
J. MICHAEL MCQUADE, Vice President, Research
SCOTT MORY, Vice President, University Advancement
KEY NUTTALL, Vice President, Marketing & Communications
DARYL WEINERT, Chief of Staff and Vice President, Strategic Initiatives

University Leadership Council

AMY L. BURKERT, Vice Provost for Education
JONATHAN CAGAN, Interim Dean, College of Engineering
ROBERT DAMMON, Dean, Tepper School of Business
REBECCA DOERGE, Dean, Mellon College of Science
MARTIAL HEBERT, Dean, School of Computer Science
RAMAYYA KRISHNAN, Dean, Heinz College of Information Systems and Public Policy
DAN J. MARTIN, Dean, College of Fine Arts
RICHARD SCHEINES, Dean, Dietrich College of Humanities and Social Sciences
MARTIAL HEBERT, Dean, School of Computer Science
JEANETTE VANBRIESEN, Vice Provost for Faculty
KEITH WEBSTER, Dean, University Libraries and Director of Emerging and Integrative Media Initiatives

Officers of the Board of Trustees

JAMES E. ROHR, Chair
EDWARD H. FRANK, Vice Chair
TOD S. JOHNSON, Vice Chair
FARNAM JAHANIAN, President
JAMES H. GARRETT, JR., Provost and Chief Academic Officer
ANGELA BLANTON, Vice President and Chief Financial Officer
GINA CASALEGNO, Vice President and Dean of Student Affairs
MARY JO DIVELY, Vice President and General Counsel
JOHN DOLAN, Treasurer
CHARLES A. KENNEDY, Chief Investment Officer
CATHY LIGHT, Secretary of the Corporation and Advisor to the President
J. MICHAEL MCQUADE, Vice President for Research
RODNEY MCCLENDON, Vice President for Operations
SCOTT MORY, Vice President for University Advancement
CARRIE NELSON, Assistant Treasurer
KEY NUTTALL, Vice President for Marketing and Communications
DARYL WEINERT, Chief of Staff and Vice President for Strategic Initiatives

Voting Trustees
JOEL ADAMS, General Partner, Adams Capital Management, Inc
LANE M. BESS, Principal and Founder, Bess Ventures and Advisory
RONALD BIANCHINI, JR., Distinguished Engineer, Microsoft Corporation
KEITH BLOCK, Co-Chief Executive Officer Salesforce
FRANK BRUNCKHORST, Boar’s Head Provisions Co., Inc.
DAVID COULTER, Special Limited Partner, Warburg Pincus LLC
RUSSELL CROCKETT, Senior Advisor, RTC Energy LLC
JEANNE CUNICELLI, Executive Vice President, UPMC Pincus LLC
ERROLL B. DAVIS, JR., Senior Advisor, TalentQuest, Inc.
SHRINIVAS V. DEMPLO, Chairman and Managing Director, Dempo Group of Companies
GLEN DE VRIES, President, Medidata Solutions
LINDA A. DICKERSON, Principal, 501(c)(3)2
FRANCISCO D’SOUSA, CEO, Cognizant Technology Solutions
HOWARD L. ELLIN, Partner, Skadden Arps Slate Meagher and Flom
EDWARD H. FRANK, Founder and Vintner, Compass Vineyards; Co-founder and CEO, Cloud Parity, Inc.
YOSHIKI FUJIMORI, Senior Advisor, LIXIL Group Corporation
ERIC GILER, Chairman and CEO, Speedy Packets, Inc
EDWARD J. GRENFETT, President and COO, The Dietrich Foundation
IRA J. GUMBERG, Chairman and CEO, I.J. Gumberg Co.
JEFFREY HOUSENBOLD, Managing Director, SoftBank
TORRENCE M. HUNT, JR., The Elmhurst Group, The Roy A. Hunt Foundation
LARRY E. JENNINGS, JR., Senior Managing Director, ValStone Partners, LLC
TOD S. JOHNSTON, Executive Chairman, The NPD Group, Inc.
RAYMOND J. LANE, Managing Partner, GreatPoint Ventures
BRUCE MCWILLIAMS, Chief Executive Officer, Bosa Nova
ANNE M. MOLLOY, Executive Director, Posner Fine Arts Foundation
DAVID PORGES, Executive Chairman, EQT Corporation
JAMES E. ROHR, Retired Chairman and CEO, The PNC Financial Services Group, Inc.
JONATHAN ROTHBERG, Founder and Chairman, Butterfly Networks, LAM Therapeutics, Quantum-Si, Hyperfine Research, and 4 Combinator
AJIT SHETTY, Retired Chairman of the Board, Janssen Pharmaceutica
J. LEA HILLMAN SIMMONS, Chair, Hillman Family Foundations
MANOJ SINGH, Retired Chief Operating Officer, Deloitte Touche Tohmatsu Limited
LUKE SKURMAN, CEO, Niche
LIP-BU TAN, CEO, Cadence Design Systems
DAVID TEPPER, President and Founder, Appaloosa Management L.P.
THOMAS TULL, Chairman and CEO, Tulco
MARY ANN ULISHNEY, Vice President and Wealth Specialist, Wells Fargo Bank, NA Private Client Service
SUNIL WADHWANI, Managing Director, SWAT Capital
PAULA KAUFFMAN WAGNER, Producer/Owner, Chestnut Ridge Productions
MICHAEL ZAMAGIAS, Founder, Chairman and CEO, Zamagias Properties

Ex-Officio Trustees
RANDAL BRYANT, Chair, Faculty Senate, Carnegie Mellon University
ALEX DICLAUDIO, President, Carnegie Mellon Alumni Association
FARNAHAM JAHANIAN, President
BRUCE KRAUS, President, Pittsburgh City Council
BRYON KURG, President, Andrew Carnegie Society
WILLIAM PEDUTO, Mayor, City of Pittsburgh

Emeritus Trustees
JOHN R. BERTUCCI, Chairman, MKS Instruments, Inc.
CAROL R. BROWN, Former President, Pittsburgh Cultural Trust
ROBERT M. BROWN, III, Retired Managing Director, Lehman Brothers
W. LOGAN DICKERSON, President, Lindwood Farm, Inc. & Protos Foods, Inc.
PHILIP L. DOWD, Sherick Enterprises, LLC
DINA DUBLON
WILLIAM B. ELLIS, Retired Chairman and CEO, Northeast Utilities
CYNTHIA FRIEDMAN, Co-owner, Union Real Estate Company of Pittsburgh
HENRY J. GAILLIOT
CLAIRE W. GARGALLI
RICHARD D. HAMILTON, Retired Director of Product Supply, Global OleoChemical Group, Procter and Gamble
THERESA HEINZ, Chairman, The Heinz Endowments, Heinz Family Philanthropies
ORION L. HOCH, Chairman Emeritus, Litton Industries
T. JEROME HOLLERAN, Retired Chairman, Precision Medical Products, Inc.
W. LEE HOSKINS, Retired Chairman and CEO, The Huntington National Bank
JUSTIN M. JOHNSON, Retired Judge, Superior Court of Pennsylvania
PATRICIA ASKWITH KENNER, President, Campus Coach Lines
DAVID M. KIRK, Partner, Kirr, Marbach & Company
EDWARD E. LUCENTE
THOMAS A. MCCONOMY, Retired Chairman of the Board, Calgon Carbon Corporation
JACK E. MCGRAV, Retired Senior Vice President, Booz, Allen & Hamilton
REGINA GOUGER MILLER, Owner/Artist, Ginger and Spice; Regina Gouger Miller Studio
ALESSANDRO OVI, Executive Vice President, Fondazione Popoli
E. KEARS POLLOCK, Retired Executive Vice President, PPG Industries, Inc.
CHARLES J. QUEENAN, JR., ESQ., Chairman Emeritus, K&L Gates LLP
JOHN G. RANGOS, SR., John G. Rangos, Sr. Charitable Foundation
DAVID M. RODERICK, Former Chairman and CEO, United States Steel Corporation
VINCENT A. SARNI, Retired Chairman and CEO, PPG Industries, Inc.
JOYCE B. SCOTT, J. Bowie Scott Studio
DAVID S. SHAPIRA, Executive Chairman, Board of Directors, Giant Eagle, Inc.
RAYMOND SMITH, Chairman, Rothschild Continuation Investments
W. LOWELL STEINBRENNER, Retired Chairman, Contours, Ltd.

2019-2020 Undergraduate Catalog
DONALD E. STITZENBERG, Principal, CBA Associates
JAMES M. WALTON, President Emeritus, Carnegie Institute
KONRAD M. WEIS, Former President and CEO, Bayer Corporation