ACADEMIC CATALOG

2023/2024

ASHESI

Table of Contents

Ashesi University 2023-2024 Academic Catalog

ACADEMIC PROGRAMS, DEGREES, AND DEGREE REQUIREMENTS

Mission & Vision Statements

The mission of Ashesi University is to educate a new generation of ethical, entrepreneurial leaders in Africa; to cultivate within our students the critical thinking skills, the concern for others and the courage it will take to transform a continent.

Our vision is an African renaissance driven by a new generation of ethical, entrepreneurial leaders. We aim to educate such leaders and to drive a movement in African higher education to scale up the education of such leaders.

Academic Message

An Ashesi student's academic purpose is striving for excellence in citizenship, leadership, and scholarship to transform Africa.

Ashesi University Academic and Social Honor Codes

Academic Honor Code (2007): All members of each second-year class at Ashesi University vote on whether to pledge to abide by the Academic Honor Code. When a minimum of 66.7% of the class votes in favor of the pledge, the entire class is deemed committed to honoring the pledge, which simply states, “I will not cheat, and I will not allow my peers to cheat.”

Social Honor Code (2018): Under the **code**, all members of the **Ashesi** community will now sign on to a new **pledge** of behavior; the **pledge** reads, "As a member of the **Ashesi** Community, I will act with honesty, integrity, and respect for others, and will hold my peers accountable to abide by these principles and by the **university's code** of conduct."

Undergraduate Degrees Offered

Bachelor of Science (BSc.)

Department of Business Administration

BSc. in Business Administration

Department of Computer Science and Information Systems

BSc. in Computer Science
BSc. in Management Information Systems

Department of Engineering

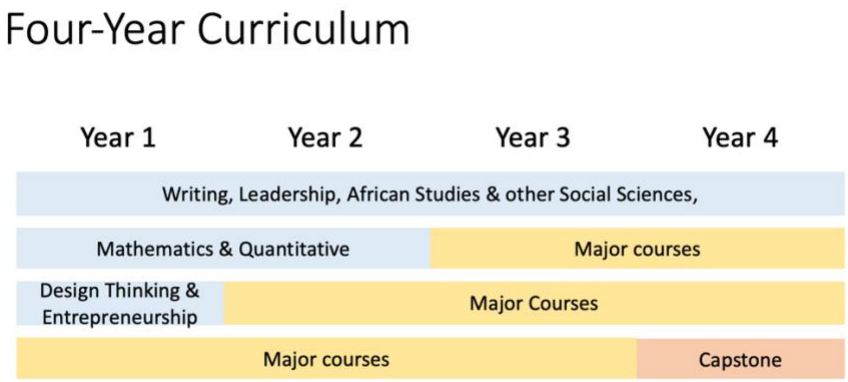
BSc. in Computer Engineering
BSc. in Electrical & Electronic Engineering
BSc. in Mechanical Engineering

Graduate Degrees Offered

MSc. in Mechatronic Engineering
MAS in Mechatronic Engineering
MPhil. in Mechatronic Engineering

Bachelor's Degree Requirements

Ashesi University offers an academic program consisting of a minimum of 134 semester hours (33.5 semester units) of credit for the bachelor's degree. The degree consists of a hybrid of foundational liberal arts core concentrated in year one, a professional core in a major, and elective courses.



Ashesi's academic calendar of 32 weeks a year is divided into two semesters, e.g., 16 weeks each, or 15 and 17 weeks, or 14 and 18 weeks. Post-COVID variations in the year one calendar have occurred to respond to the schedule of the national university entrance examinations. Students typically take four-semester units per semester. A semester unit for a 16-week semester is 42 (3 hrs. X 14 weeks) classroom contact hours and a range of 14 discussion hours to 42 lab contact hours.

In the European Credit Transfer and Accumulation System, ECTS, (using 1 ECTS = 25 hours) each of our degree programs is approximately 240 ECTS. (See page 75)

To earn a baccalaureate degree and be eligible for graduation, students are required to fulfil the following minimal requirements.

- Successful completion of at least **33.5** semester units, including all core and major requirements*
- A cumulative grade point average of 2.0 (C average) or higher
- Successful completion of the service-learning component**
- Successful completion of internship (required only for engineering students) ***
- Successful completion of writing across the curriculum course series (required pass for class of 2024 and subsequent classes) ****
- Fulfillment of all financial obligations to the University.

  ** Note that some Ashesi degree programs require more than **33.5** units, depending on a student's math track.*

  ***The **service-learning** component exists as another dimension of our commitment to nurturing graduates who excel in citizenship. Service learning helps students develop a sense of citizenship by giving them an opportunity to become engaged with their surrounding community. Students must complete 40 hours of community service and fulfill this requirement in a variety of ways. The Outreach and Experiential Learning Programs office keeps a directory of non-profit organizations students can volunteer with.*

  **** All Ashesi students are strongly encouraged to take up summer **internship** opportunities at the end of their second and third years. To ensure some level of familiarity with the practicing engineering profession, all Ashesi engineering students are required to either do an internship at an engineering firm or an engineering-related internship at a non-engineering firm, shadow a practicing engineer, or engage in an engineering project for an external company.*

  ***** Beginning with the Class of 2024, all Ashesi students should obtain a pass in the Writing Across the Curriculum Lab series as a graduation requirement.*

Graduation Honors

Students who earn a cumulative GPA of 3.50 to 3.69 for all undergraduate work earn ***Cum Laude*** (honors). Those with a cumulative GPA of 3.70 to 3.84 for all undergraduate work earn ***Magna Cum Laude*** (high honors). Students with a cumulative GPA of 3.85 or above for all undergraduate work earn ***Summa Cum Laude*** (highest honors).

Summa Cum Laude: 3.85-4.00 (Highest Honors)

Magna Cum Laude: 3.70-3.84 (High Honors)

Cum Laude: 3.50-3.69 (Honors)

Bachelor's Degree: 2.00-3.49

Cum Laude and Class Distinctions

Ashesi University Honors	GPA	Public University (University of Cape Coast Honors)	GPA
Summa Cum Laude (Highest Honors)	3.85-4.00		
Magna Cum Laude (High Honors)	3.70-3.84	First Class	3.60 - 4.00
Cum Laude (Honors)	3.50-3.69	Second Class (Upper)	2.95 – 3.59
Bachelor's	2.00-3.49	Second Class (Lower)	2.45 – 2.94
		Third Class	2.00 – 2.44

Overview of Courses Offered in Ashesi's Six Undergraduate Degree Programs

		Business Administration	Management Information System	Computer Science	Computer Engineering	Electrical and Electronic Engineering	Mechanical Engineering
LIBERAL ARTS & SCIENCES CORE	Humanities & Social Sciences	Written and Oral Comm. Text and Meaning Ashesi Seminar & Leadership 1* Leadership 2* Leadership 3* Leadership 4 Microeconomics Macroeconomics *6.5 Ashesi Units*	Written and Oral Comm. Text and Meaning Ashesi Seminar & Leadership 1* Leadership 2* Leadership 3* Leadership 4 Microeconomics Macroeconomics *6.5 Ashesi Units*	Written and Oral Comm. Text and Meaning Ashesi Seminar & Leadership 1* Leadership 2* Leadership 3* Leadership 4 Principles of Economics *5.5 Ashesi Units*	Written and Oral Comm. Text and Meaning Ashesi Seminar & Leadership 1* Leadership 2* Leadership 3* Leadership 4 (for Engineers) Principles of Economics *5.5 Ashesi Units*	Written and Oral Comm. Text and Meaning Ashesi Seminar & Leadership 1* Leadership 2* Leadership 3* Leadership 4 (for Engineers) Principles of Economics *5.5 Ashesi Units*	Written and Oral Comm. Text and Meaning Ashesi Seminar & Leadership 1* Leadership 2* Leadership 3* Leadership 4 (for Engineers) Principles of Economics *5.5 Ashesi Units*
	Business	Found. Of Design & Entre. I Found. Of Design & Entre. II *2 Ashesi Units*	Found. Of Design & Entre. I Found. Of Design & Entre. II *2 Ashesi Units*	Found. Of Design & Entre. I Found. Of Design & Entre. II Finance for Non-Finance Mgrs *3 Ashesi Units*	Found. Of Design & Entre. I Found. Of Design & Entre. II *2 Ashesi Units*	Found. Of Design & Entre. I Found. Of Design & Entre. II *2 Ashesi Units*	Found. Of Design & Entre. I Found. Of Design & Entre. II *2 Ashesi Units*
	Mathematics	Pre-Calculus 1 / Calculus 1 Pre-Calculus 2 / Calculus 2 Applied Calc (*Pre-Calc track only)* Statistics Quantitative Methods *4 Ashesi Units* *(5 if Pre-Calc track)*	Pre-Calculus 1 / Calculus 1 Pre-Calculus 2 / Calculus 2 Applied Calc (*Pre-Calc track only)* Statistics Quantitative Methods *4 Ashesi Units* *(5 if Pre-Calc track)*	Pre-Calculus 1 / Calculus 1 Pre-Calculus 2 / Calculus 2 Applied Calc (*Pre-Calc track only)* Statistics Quantitative Methods OR Linear Algebra *4 Ashesi Units* *(5 if Pre-Calc track)*	Calculus for Engineering / Calc 1 Calculus 2 (only if Calculus 1) Multivariable Calc. & Linear Alg Diff. Eqs. & Numerical Methods Statistics for Engineering *4 Ashesi Units* *(5 if Calc 1&2 track)*	Calculus for Engineering / Calc 1 Calculus 2 (only if Calculus 1) Multivariable Calc. & Linear Alg Diff. Eqs. & Numerical Methods Statistics for Engineering *4 Ashesi Units* *(5 if Calc 1&2 track)*	Calculus for Engineering / Calc 1 Calculus 2 (only if Calculus 1) Multivariable Calc. & Linear Alg Diff. Eqs. & Numerical Methods Statistics for Engineering *4 Ashesi Units* *(5 if Calc 1&2 track)*
	Computing	Intro to Computing & IS 1 Ashesi Unit	Intro to Computing & IS 1 Ashesi Unit	Intro to Computing & IS 1 Ashesi Unit	Computer Programming for Eng. 1 Ashesi Unit	Computer Programming for Eng. 1 Ashesi Unit	Computer Programming for Eng. 1 Ashesi Unit
	Science	*0 Ashesi Unit*	*0 Ashesi Unit*	*0 Ashesi Unit*	Engineering Mechanics Electromagnetism Material Science & Chemistry *3 Ashesi Units*	Engineering Mechanics Electromagnetism Material Science & Chemistry *3 Ashesi Units*	Engineering Mechanics Electromagnetism Material Science & Chemistry *3 Ashesi Units*
	Research / Project Prep.	Research Methods *1 Ashesi Unit*	Research Methods *1 Ashesi Unit*	Research Methods *1 Ashesi Unit*	3rd Yr. Grp. Project & Seminar* *0.5 Ashesi Unit*	3rd Yr. Grp. Project & Seminar* *0.5 Ashesi Unit*	3rd Yr. Grp. Project & Seminar* *0.5 Ashesi Unit*
		3 Non-Major Electives including at least 1 African studies *3 Ashesi Units*	3 Non-Major Electives including at least 1 African studies *3 Ashesi Units*	3 Non-Major Electives including at least 1 African studies *3 Ashesi Units*	2 Non-Major Electives including at least 1 African studies *2 Ashesi Units*	2 Non-Major Electives including at least 1 African studies *2 Ashesi Units*	3 Non-Major Electives including at least 1 African studies *2 Ashesi Units*
	Total Credits (Liberal Arts & Sciences)	**17.5 Ashesi Units** **(18.5 if Pre-Calc Track)**	**17.5 Ashesi Units** **(18.5 if Pre-Calc Track)**	**17.5 Ashesi Units** **(18.5 if Pre-Calc Track)**	**18 Ashesi Units** **(19 if Calc 1 & Calc 2 Track)**	**18 Ashesi Units** **19 if Calc 1 & Calc 2 Track)**	**18 Ashesi Units** **19 if Calc 1 & Calc 2 Track)**
MAJOR	Required Major Classes	Introduction to Finance Financial Accounting Marketing Managerial Accounting Corporate Finance Organizational Behavior International Trade & Policy Operations Management Business Law Competitive Strategy Investments *11 Ashesi Units*	Finance for Non-Finance Managers Managerial Accounting Competitive Strategy Computer Programming for CS Discrete Structures & Theory Database Management Web Technologies Systems Analysis & Design Information & Systems Security E-Commerce IT Infrastructure & Systems Administration Lab IS Project Management Introduction to Artificial Intelligence *12 Ashesi Units*	Computer Programming for CS Discrete Structures and Theory Data Structures & Algorithms Computer Org. & Arch. Software Engineering Database Systems Intermediate Comp. Prog. Web Technologies Networks & Data Comm. Operating Systems Introduction to Artificial Intelligence Introduction to Modelling and Simulation Algorithm Design & Analysis *12 Ashesi Units*	Introduction to Engineering Instrumentation for Engineering* Applied Programming for Eng.* System Dynamics Control Systems Digital Systems Design Circuits & Electronics Project Mgmt. & Prof. Practice Embedded Systems Data Structures & Algorithms Operating Systems Networks & Distr. Computing Communication Systems Computer Org. & Arch. *13 Ashesi Units*	Introduction to Engineering Instrumentation for Engineering* Applied Programming for Eng.* System Dynamics Control Systems Digital Systems Design Circuits & Electronics Project Mgmt. & Prof. Practice Embedded Systems Intro to Electrical Machines & Power Electronics Advanced Electrical machines & Power Electronics Fundamentals of Thermal Fluid Science & Heat Transfer Communications Systems Power Engineering *13 Ashesi Units*	Introduction to Engineering Instrumentation for Engineering* Applied Programming for Eng.* System Dynamics Control Systems Digital Systems Design Circuits & Electronics Project Mgmt. & Prof. Practice Mechanical machine Design Intro to Electrical Machines & Power Electronics Fluid Dynamics & Applications Fundamentals of Thermal Fluid Science & Heat Transfer Mechanics of Materials / Structural Engineering Thermal Systems & Applications *13 Ashesi Units*
	Major Electives	3 BA Electives *3 Ashesi Units*	2 MIS Electives *2 Ashesi Units*	2 CS Electives *2 Ashesi Unit*	2 CE Electives *2 Ashesi Unit*	2 EE Electives *2 Ashesi Unit*	2 ME Electives *2 Ashesi Unit*
	Capstone	Capstone 1 (could be electives) Capstone 2 *2 Ashesi Units*	Capstone 1 (could be electives) Capstone 2 *2 Ashesi Units*	Capstone 1 (could be electives) Capstone 2 *2 Ashesi Units*	Capstone *2 Ashesi Units*	Capstone *2 Ashesi Units*	Capstone *2 Ashesi Units*
	Total Credits (Major)	**16 Credits**	**16 Credits**	**16 Credits**	**16 Credits**	**16 Credits**	**16 Credits**
	TOTAL CREDITS OVERALL	**33.5 Ashesi Units** **(34.5 if Pre-Calc track)**	**33.5 Ashesi Units** **(34.5 if Pre-Calc track)**	**33.5 Ashesi Units** **(34.5 if Pre-Calc track)**	**34 Ashesi Units** **(35if Calc 1 & Calc 2 Track)**	**34 Ashesi Units** **35 if Calc 1 & Calc 2 Track)**	**34 Ashesi Units** **35 if Calc 1 & Calc 2 Track)**

Business Administration, Management Information Systems, & Computer Science Programs: New 4-Year Curriculum (Transition Plan for Class of 2022)

Semester	Business Administration	Management Information System	Computer Science
Year 1			
Sem 1 Aug - Dec	Ashesi Success Pre-Calculus I or Calculus I Written and Oral Communication Foundations Design & Entrepreneurship 1 Introduction to Computing and Information Systems		
Sem 2 Jan - May	Leadership Seminar 1* Precalculus 2 or Calculus 2 Text and Meaning Foundations of Design and Entrepreneurship II		
	Organizational Behavior	Computer Programming for CS	Computer Programming for CS
Summer	Applied Calculus (Pre-Calculus Students only)		
Year 2			
Sem 1 Aug - Dec	Leadership Seminar 2* Statistics Microeconomics Financial Accounting **Non-Major Elective**[1]	Leadership Seminar 2* Statistics Microeconomics Discrete Structures & Theory **Non-Major Elective**[1] or Data Structures[2]	Leadership Seminar 2* Statistics Data Structures & Algorithms Discrete Structures & Theory **Non-Major Elective**[1] or Microeconomics[3]
Sem 2 Jan - May	Leadership Seminar 3* Quantitative Methods Macroeconomics Marketing[1] Introduction to Finance	Leadership Seminar 3* Quantitative Methods Macroeconomics[1] Database Systems Finance for non-Finance Managers	Leadership Seminar 3* Quantitative Methods or Multivariable Calculus & Linear Algebra Intermediate Comp Prog Database Systems Finance for non-Finance Managers[1]
Year 3			
Sem 1 Aug - Dec	International Trade & Policy Operations Management Investments Leadership Seminar 4 or **Elective†**	**Elective†** Web Technologies Systems Analysis & Design Leadership Seminar 4 or **Elective†**	Research Methods Web Technologies Computer Org & Architecture Leadership Seminar 4 or **Elective†**
Sem 2 Jan - May	Managerial Accounting Research Methods Elective† Leadership Seminar 4 or **Elective†**	Research Methods IT Infrastructure Systems Administration Lab* IS Project Management* Leadership Seminar 4 or Managerial Accounting **†**	Software Engineering Algorithms Design & Analysis Principles of Economics Leadership Seminar 4 or **Elective†**
Year 4			
Sem 1 Aug - Dec	Corporate Finance Business Law **Elective†** Capstone 1	E-Commerce Information and Systems Security **Elective†** Capstone 1	Operating Systems Human Computer Interaction **Elective†** Capstone 1
Sem 2 Jan - May	Competitive Strategy **Elective†** **Elective†** Capstone 2	Competitive Strategy **Elective†** **Elective†** Capstone 2	Networks & Data Communications **Elective†** **Elective†** Capstone 2

* Half-credit course

[1] Students who wish to study French will take *Beginning French 1* as their non-major elective in Year 2 Sem 1. To continue with *Beginning French 2* in Year 2 Sem 2, they will postpone one required course (*Marketing* for BA majors, *Macroeconomics* for MIS majors, and *Finance for Non-Finance Managers* for CS majors) to the summer or to the elective slot in Year 3 Sem 2. They can continue with their study of French by taking *Professional French 1* and *Professional French 2* as course overloads in Year 3. Alternatively, they can free up space for French in Year 3 by taking summer courses after Year 2.

[2] Data Structures counts as a major elective for MIS majors and is encouraged for those who plan to do software development or those entering Year 2 who are still unsure about whether to major in MIS or CS

[3] Although *Principles of Economics* is prescribed for CS majors, *Microeconomics* can be substituted. As such, *Microeconomics* is recommended for students entering Year 2 who are still unsure about whether to major in CS or MIS

† Students have flexibility in scheduling electives (major and non-major) in Years 3 and 4 but must ensure that they take the total required number of major electives (3 for BA, 2 for MIS & CS) and non-major electives (3, including at least 1 Africana).

Business Administration, Management Information Systems, & Computer Science Programs: New 4-Year Curriculum (Transition Plan for Class of 2023)

Sem	BA	MIS	CS
Year 1			
Sem 1	Giving Voice to Values Precalculus 1 or Calculus 1 Written & Oral Communication Foundations of Design and Entrepreneurship I Introduction to Computing and Information Systems		
Sem 2	Leadership Seminar 1* Precalculus 2 or Calculus 2 Text and Meaning Foundations of Design and Entrepreneurship II Organizational Behavior	Computer Programming for CS	Computer Programming for CS
Summer	Applied Calculus (Pre-Calculus Students only)		
Year 2			
Sem 1	Leadership Seminar 2* Statistics Microeconomics Financial Accounting **Non-Major Elective**[1]	Leadership Seminar 2* Statistics Microeconomics Discrete Structures & Theory **Non-Major Elective**[1] or Data Structures[2]	Leadership Seminar 2* Statistics Data Structures & Algorithms Discrete Structures & Theory **Non-Major Elective**[1] or Microeconomics[3]
Sem 2	Leadership Seminar 3* Quantitative Methods Macroeconomics Marketing[1] Introduction to Finance	Leadership Seminar 3* Quantitative Methods Macroeconomics[1] Database Systems Finance for non-Finance Managers	Leadership Seminar 3* Linear Algebra Intermediate Comp Prog Database Systems Finance for non-Finance Managers[1]
Year 3			
Sem 1	**Elective**† Operations Management Investments Leadership Seminar 4 or **Elective**†	Managerial Accounting Web Technologies Systems Analysis & Design Leadership Seminar 4 or **Elective**†	Human Computer Interaction Web Technologies Computer Org & Architecture Leadership Seminar 4 or **Elective**†
Sem 2	Managerial Accounting International Trade & Policy Research Methods Leadership Seminar 4 or **Elective**†	IT Infrastructure Systems Administration Lab* IS Project Management* Research Methods Leadership Seminar 4 or **Elective**†	Software Engineering Algorithm Design & Analysis Research Methods Leadership Seminar 4 or **Elective**†
Year 4			
Sem 1	Corporate Finance Business Law **Elective**† Capstone 1 (Entrepreneurship 1/ Thesis 1/ Extra major elective)	E-Commerce Information and Systems Security **Elective**† Capstone 1 (Entrepreneurship 1/ Thesis 1/ Extra major elective)	Operating Systems Principles of Economics **Elective**† Capstone 1 (Entrepreneurship 1/ Thesis 1/ Extra major elective)
Sem 2	Competitive Strategy **Elective**† **Elective**† Capstone 2 (Entrepreneurship 2/ Thesis 2/ Applied Project)	Competitive Strategy **Elective**† **Elective**† Capstone 2 (Entrepreneurship 2/ Thesis 2/ Applied Project)	Networks & Data Communications **Elective**† **Elective**† Capstone 2 (Entrepreneurship 2/ Thesis 2/ Applied Project)

* Half-credit course

[1] Students who wish to study French will take *Beginning French 1 & 2* in Year 2, postponing one required course (*Marketing* for BA, *Macroeconomics* for MIS, and *Finance for Non-Finance Managers* for CS) to the summer or to Year 3 Sem 2. They can take courses in Year 2 Summer to free up space to take *Professional French 1* & *2* in Year 3 or can do these courses as an overload.

[2] Data Structures is a major elective for MIS majors and is encouraged for those who plan to engage in software development.

[3] Although *Principles of Economics* is prescribed for CS majors, *Microeconomics* can be substituted. As such, *Microeconomics* is recommended for students entering Year 2 who are still unsure about whether to major in CS or MIS

† Students have flexibility in scheduling electives (major and non-major) in Years 3 and 4 but must ensure that they take the total required number of major electives (3 for BA, 2 for MIS & CS) and non-major electives (3, including at least 1 Africana).

Management Information Systems, & Computer Science Programs:
4-Year Curriculum (with Pre-matriculation Semester) – Class of 2024

Semester	Management Information System	Computer Science
Year 1		
Pre-Matriculation Semester Aug 2020 - Jan 2021	Entrepreneurship Universe Writing, Public Speaking and Multimedia Communication Creative Approaches to African Development Introduction to Computing and Information Systems Principles of Design Quantitative Estimation and Data Visualization **Optional Modules:** How to Communicate like a Leader Math Bridge for ENG English Bridge	
Sem 1 Jan 2021– May 2021	Ashesi Success Pre-Calculus I or Calculus I Written and Oral Communication Foundations Design & Entrepreneurship 1 Introduction to Computing and Information Systems Leadership Seminar 1	
Sem 2 Aug 2021- Dec2021	Text and Meaning Precalculus 2 or Calculus 2 Leadership Seminar 1* (Class of 2025) Foundations of Design and Entrepreneurship II Computer Programming for CS	
Year 2		
Sem 1 Jan 2022– May 2022	Leadership Seminar 2* Statistics Microeconomics Discrete Structures & Theory Non-Major Elective or Data Structures	Leadership Seminar 2* Statistics Data Structures & Algorithms Discrete Structures & Theory Non-Major Elective or Microeconomics
Summer	Applied Calculus (Pre-Calculus Students only)	
Sem 2 Aug 2022- Dec2022	Leadership Seminar 3* (Class of 2025) Quantitative Methods Macroeconomics Database Systems Introduction to Artificial Intelligence	Leadership Seminar 3* (Class of 2025) Linear Algebra Intermediate Comp Prog Database Systems Introduction to Artificial Intelligence
Year 3		
Sem 1 Jan 2023– May 2023	Finance for non-Finance Managers Web Technologies Systems Analysis & Design Leadership Seminar 4 or Elective 	Finance for non-Finance Managers Web Technologies Computer Org & Architecture Leadership Seminar 4 or Elective Introduction to Modelling & Simulation*
Sem 2 Aug 2023- Dec2023	Research Methods IT Infrastructure & Systems Administration IS Project Management Leadership Seminar 4 or Elective	Research Methods Algorithms Design & Analysis Software Engineering Leadership Seminar 4 or Elective
Year 4		
Sem 1 Jan 2024– May 2024	E-Commerce Information and Systems Security Elective Capstone 1 (Entrepreneurship 1 / Thesis 1/ Extra major elective)	Operating Systems Principles of Economics Elective Capstone 1 (Entrepreneurship 1 / Thesis 1/ Extra major elective)
Sem 2 Aug 2024 - Dec2024 Aug 2025 - Dec2025	Competitive Strategy Elective Elective Capstone 2 (Entrepreneurship 2 / Thesis 2/ Extra major elective)	Networks & Data Communications Elective Elective Capstone 2 (Entrepreneurship 2 / Thesis 2/ Extra major elective)

Management Information Systems, & Computer Science Programs:
4-Year Curriculum (with Pre-matriculation Semester) – Class of 2025 and later classes

Semester	Management Information System	Computer Science
Year 1		
Pre-Matriculation Semester	Entrepreneurship Universe Writing, Public Speaking and Multimedia Communication Creative Approaches to African Development Introduction to Computing and Information Systems Principles of Design Quantitative Estimation and Data Visualization **Optional Modules:** How to Communicate like a Leader Math Bridge for ENG English Bridge	
Sem 1 (Jan – May)	Ashesi Success Pre-Calculus I or Calculus I Written and Oral Communication Foundations Design & Entrepreneurship 1 Introduction to Computing and Information Systems	
Sem 2 (Aug – Dec)	Text and Meaning Precalculus 2 or Calculus 2 Leadership Seminar 1* Foundations of Design and Entrepreneurship II Computer Programming for CS	
Year 2		
Sem 1 (Jan – May)	Leadership Seminar 2* Statistics Object-Oriented Programming Discrete Structures & Theory Principles of Economics	Leadership Seminar 2* Statistics Object Oriented Programming Discrete Structures & Theory Principles of Economics
Summer	Applied Calculus (Pre-Calculus Students only)	
Sem 2 (Aug – Dec)	Leadership Seminar 3* (Class of 2025) Quantitative Methods Non-Major Elective[1] or Data Structures[2] Database Systems Introduction to Artificial Intelligence	Leadership Seminar 3* (Class of 2025) Linear Algebra Data Structures & Algorithms Database Systems Introduction to Artificial Intelligence
Year 3		
Sem 1 (Jan – May)	Finance for non-Finance Managers Web Technologies Systems Analysis & Design Leadership Seminar 4 or Elective† 	Intermediate Computer Programming Web Technologies Algorithm Design & Analysis Leadership Seminar 4 or Elective† Systems Fundamentals*
Sem 2 (Aug – Dec)	IS Project Management IT Infrastructure & Systems Administration Research Methods Leadership Seminar 4 or Elective†	Software Engineering Computer Organization & Architecture Research Methods Leadership Seminar 4 or Elective†
Year 4		
Sem 1 (Jan – May)	E-Commerce Information and Systems Security Elective† Capstone 1 (Entrepreneurship 1 / Thesis 1/ Extra major elective)	Operating Systems Finance for non-Finance Managers Elective† Capstone 1 (Entrepreneurship 1 / Thesis 1/ Extra major elective)
Sem 2 (Aug – Dec)	Competitive Strategy Elective† Elective† Capstone 2 (Entrepreneurship 2 / Thesis 2 / Extra major elective)	Networks & Data Communications Elective† Elective† Capstone 2 (Entrepreneurship 2 / Thesis 2 / Extra major elective)

Computer Engineering, Electrical and Electronic Engineering, and Mechanical Engineering Programs: New 4-Year Curriculum (Transition Plan for Class of 2022 and Class of 2023)

	Year 1 Experience		
	Math Bridge for Engineering		
	Quantitative Estimation & Data Visualization		
	Principles of Design		
	Information Technology		
Year 1	**CE**	**EE**	**ME**
Sem 1	Written and Oral Communication	Written and Oral Communication	Written and Oral Communication
Jan	Calculus for Engineering	Calculus for Engineering	Calculus for Engineering
	Introduction to Engineering	Introduction to Engineering	Introduction to Engineering
	GVV	GVV	GVV
	Foundations Design & Entrepreneurship 1	Foundations Design & Entrepreneurship 1	Foundations Design & Entrepreneurship 1
Sem 2	Computer Programming for Engineering	Computer Programming for Engineering	Computer Programming for Engineering
Aug	Multivariable Calculus & Linear Algebra	Multivariable Calculus & Linear Algebra	Multivariable Calculus & Linear Algebra
	Engineering Mechanics	Engineering Mechanics	Engineering Mechanics
	Foundations Design & Entrepreneurship 2	Foundations Design & Entrepreneurship 2=	Foundations Design & Entrepreneurship 2
	Leadership Seminar 1*	Leadership Seminar 1*	Leadership Seminar 1*
Year 2	CE	EE	ME
Sem 1	Physics: Electromagnetism	Physics: Electromagnetism	Physics: Electromagnetism
Jan	Discrete Math	CAD/CAM	CAD/CAM
	Statistics for Engineering	Statistics for Engineering	Statistics for Engineering
	Object Oriented Programming (Java)	Thermodynamics	Thermodynamics
	Leadership Seminar 2*.	Leadership Seminar 2*	Leadership Seminar 2*
Sem 2	Circuits and Electronics	Circuits and Electronics	Circuits and Electronics
Aug	Materials Science & Chemistry	Materials Science & Chemistry	Materials Science & Chemistry
	Differential Eqs & Numerical Methods	Differential Eqs & Numerical Methods	Differential Eqs & Numerical Methods
	Applied Programming for Engineers*	Applied Programming for Engineers*	Applied Programming for Engineers*
	Text and Meaning	Text and Meaning	Text and Meaning
	Leadership Seminar 3*	Leadership Seminar 3*	Leadership Seminar 3*
Year 3	CE	EE	ME
Sem 1	Computer Organization & Architecture	Intro to Electrical Machines	Electrical Machines
Aug - Dec	System Dynamics	System Dynamics	System Dynamics
	Signals & Systems	Signals & Systems=	Mechanics of Materials
	Leadership Seminar 4 for Engineers	Leadership Seminar 4 for Engineers	Leadership Seminar 4 for Engineers
	Year 3 Group Project & Seminar*	Year 3 Group Project & Seminar*	Year 3 Group Project & Seminar*
	Instrumentation for Engineering*	Instrumentation for Engineering*	Instrumentation for Engineering*
Sem 2	Control Systems	Control Systems=	Control Systems
Jan - May	Data Structures & Algorithms	Communication Systems	Manufacturing Processes
	Networks & Data Communications	Advanced Electrical Machines	Mechanical Machine Design
	Digital Systems Design	Digital Systems Design	Fluid Mechanics
	CE Electives	EE Electives	ME Electives
Year 4			
Sem 1	Operating Systems	Power Engineering	Mechanics of Machines
Aug - Dec	CE Elective	EE Elective	ME Elective
	Principles of Economics	Principles of Economics=	Principles of Economics
	Embedded Systems	Embedded Systems =	Heat Transfer
	Elective	Elective	Elective
Sem 2	Project Mgmt and Professional Practice	Project Mgmt and Professional Practice=	Project Mgmt and Professional Practice
Jan - May	CE Elective	EE Elective	ME Elective
	African Studies Elective	African Studies Elective	African Studies Elective
	Senior Project & Seminar	Senior Project & Seminar	Senior Project & Seminar

Business Administration, Management Information Systems, & Computer Science Programs: 4-Year Curriculum (with Pre-matriculation Semester) – Class of 2024 and 2025

Semester	Business Administration	Management Information System	Computer Science
Year 1			
Pre-Matriculation Semester Aug 2020 - Jan 2021 Aug 2021 - Jan 2022	Entrepreneurship Universe Writing, Public Speaking and Multimedia Communication Creative Approaches to African Development Introduction to Computing and Information Systems Principles of Design Quantitative Estimation and Data Visualization **Optional Modules:** How to Communicate like a Leader Math Bridge for ENG English Bridge		
Sem 1 Jan 2021– May 2021 Jan 2022 –May 2022	Ashesi Success Pre-Calculus I or Calculus I Written and Oral Communication Foundations Design & Entrepreneurship 1 Introduction to Computing and Information Systems Leadership Seminar 1 (Class of 2024)		
Sem 2 Aug 2021- Dec2021 Aug 2022- Dec2022	Text and Meaning		
	Precalculus 2 or Calculus 2		
	Leadership Seminar 1* (Class of 2025)		
	Foundations of Design and Entrepreneurship II		
	Organizational Behavior	Computer Programming for CS	Computer Programming for CS
Year 2			
Sem 1 Jan 2022– May 2022 Jan 2023–May 2023	Leadership Seminar 2* (Class of 2025)	Leadership Seminar 2* (Class of 2025)	Leadership Seminar 2* (Class of 2025)
	Statistics	Statistics	Statistics
	Microeconomics	Microeconomics	Data Structures & Algorithms
	Financial Accounting	Discrete Structures & Theory	Discrete Structures & Theory
	Non-Major Elective[1]	Non-Major Elective[1] or Data Structures[2]	Non-Major Elective[1] or Microeconomics[3]
Sem 2 Aug 2022- Dec2022 Aug 2023- Dec2023	Leadership Seminar 3* (Class of 2025)	Leadership Seminar 3* (Class of 2025)	Leadership Seminar 3* (Class of 2025)
	Quantitative Methods	Quantitative Methods	Linear Algebra
	Macroeconomics	Macroeconomics[1]	Intermediate Comp Prog
	Marketing[1]	Database Systems	Database Systems
	Introduction to Finance	Finance for non-Finance Managers	Finance for non-Finance Managers[1]
Summer	Applied Calculus (Pre-Calculus Students only)		
Year 3			
Sem 1 Jan 2023– May 2023 Jan 2024–May 2024	International Trade & Policy	Managerial Accounting	Human Computer Interaction
	Operations Management	Web Technologies	Web Technologies
	Investments	Systems Analysis & Design	Computer Org & Architecture
	Leadership Seminar 4 or Elective†	Leadership Seminar 4 or Elective†	Leadership Seminar 4 or Elective†
Sem 2 Aug 2023- Dec2023 Aug 2024- Dec2024	Managerial Accounting	Research Methods	Software Engineering
	Research Methods	IT Infrastructure	Algorithms Design & Analysis
	Elective†	Systems Administration Lab*	Research Methods
		IS Project Management*	
	Leadership Seminar 4 or Elective†	Leadership Seminar 4 or Elective†	Leadership Seminar 4 or Elective†
Year 4			
Sem 1 Jan 2024– May 2024 Jan 2025 –May 2025	Corporate Finance	E-Commerce	Operating Systems
	Business Law	Information and Systems Security	Human Computer Interaction
	Elective†	Elective†	Elective†
	Capstone 1	Capstone 1 (Entrepreneurship 1 / Thesis 1/ Extra major elective)	Capstone 1 (Entrepreneurship 1 / Thesis 1/ Extra major elective)
Sem 2 Aug 2024 - Dec2024 Aug 2025 - Dec2025	Competitive Strategy	Competitive Strategy	Networks & Data Communications
	Elective†	Elective†	Elective†
	Elective†	Elective†	Elective†
	Capstone 2	Capstone 2 ((Entrepreneurship 2 / Thesis 2/ Extra major elective)	Capstone 2 ((Entrepreneurship 2 / Thesis 2/ Extra major elective)

* Half-credit course

[1] Students who have started studying French and wish to continue will take *Beginning French 2* in Year 2 Sem 2 as a non-major elective (BA majors would need to postpone *Marketing* to the summer or to the elective slot in Year 3 Sem 2). The study of French can continue in Year 3 by taking *Professional French 1* and *Professional French 2* as course overloads. Alternatively, students can free up space for French in Year 3 by taking summer courses after Year 2.

† Students have flexibility in scheduling electives (major and non-major) in Years 3 and 4 but must ensure that they ultimately have the needed number of major electives (3 for BA, 2 for MIS & CS) and non-major electives (3, including at least 1 Africana).

Updated Business Administration Department Progression Plan - Jan 2022 (Class of 2026)

Semester	Business Administration	Theory (Lecture Hours)	Practice (Lab/ Discuss)	Credit Hours	Semester Credit Hours
Year 1					
Semester 1 Sep - Dec	Ashesi Success	1.5	N/A	N/A	
	CS 111 Introduction to Computing	3	1.5	4	
	MATH 142 Calculus 1 or Pre-calculus 1	4.5	1.5	4	
	ENGL 112 Written and Oral Communication	3	1	4	
	BUSA 161A Foundation of Design & Entrepreneurship 1	3	1	4	16
Semester 2 Jan - May	ENGL 113 Text and Meaning	3	1	4	
	SOAN 111 Leadership Seminar 1*	1.5	0	2	
	BUSA 161B Foundation of Design & Entrepreneurship 2	3	1	4	
	MATH 142B Calculus 2 or Pre-Calculus 2	4.5	1.5	4	18
Semester 3	Applied Calculus (only for students who did Pre-Calculus 1 and 2)	3	1.5	4	4
Year 2					
Semester 1 Sep - Dec	ECON 101 Microeconomics	3	1	4	
	STAT 151 Statistics with Probability	3	1.5	4	
	SOAN 211 Leadership Seminar 2*	1.5	0	2	
	Non-major Elective	3	1	4	
	BUSA 210 Financial Accounting	3	1	4	18
Semester 2 Jan - May	BUSA 332 Organizational Behaviour	3	1	4	
	SOAN 311 Leadership Seminar 3*	1.5	0	2	
	BUSA 220 Introduction to Finance	3	1	4	
	MATH143 Quantitative Methods	3	1.5	4	
	ECON 102 Macroeconomics	3	1	4	18
Year 3					
Semester 1 Sep - Dec	BUSA 350 International Trade and Policy	3	1	4	
	BUSA 422 Corporate Finance	3	1	4	
	BUSA 304 Operations Management	3	1	4	20
	BUSA 341 Marketing	3	1	4	
	SOAN 411 Leadership Seminar 4 or Elective†	3	1	4	
Semester 2 Jan - May	SOAN 325 Research Methods	3	1	4	
	BUSA 311 Managerial Accounting	3	1	4	
	Elective†	3	1	4	20
	BUSA 402 Business Law	3	1	4	
	SOAN 411 Leadership Seminar 4 or Elective†	3	1	4	
Year 4					
Semester 1 Sep - Dec	BUSA 405 Competitive Strategy	3	1	4	
	BUSA 321 Investments	3	1	4	
	Elective†	3	1	4	
	Thesis 1 or Applied Project/ Business Elective or Entrepreneurship 1	1.5	1.5	4	16
Semester 2 Jan - May	Business Communication and Negotiations	3	1	4	
	Elective†	3	1	4	
	Elective†	3	1	4	
	Thesis 2 or Applied Project or Entrepreneurship 2	3	1	4	16
Total Credit Hours					**142**

Computer Engineering, Electrical and Electronic Engineering, and Mechanical Engineering Programs: 4-Year Curriculum (with Pre-matriculation Semester) – Class of 2024 and 2025

Semester	Computer Engineering	Electrical and Electronic Engineering	Mechanical Engineering
Year 1			
Pre-Matriculation Semester Aug 2020 - Jan 2021 Aug 2021 - Jan 2022	Entrepreneurship Universe Writing, Public Speaking and Multimedia Communication Creative Approaches to African Development Introduction to Computing and Information Systems Principles of Design Quantitative Estimation and Data Visualization **Optional Modules:** How to Communicate like a Leader Math Bridge for ENG English Bridge		
Sem 1 Jan 2021– May 2021 Jan 2022 –May 2022	Written and Oral Communication	Written and Oral Communication	Written and Oral Communication
	Calculus I	Calculus I	Calculus I
	Introduction to Engineering	Introduction to Engineering	Introduction to Engineering
	Giving Voice to Values	Giving Voice to Values	Giving Voice to Values
	Foundations Design & Entrepreneurship 1	Foundations Design & Entrepreneurship 1	Foundations Design & Entrepreneurship 1
Sem 2 Aug 2021- Dec2021 Aug 2022- Dec2022	Computer Programming for Engineering	Computer Programming for Engineering	Computer Programming for Engineering
	Multivariable Calculus & Linear Algebra	Multivariable Calculus & Linear Algebra	Multivariable Calculus & Linear Algebra
	Engineering Mechanics	Engineering Mechanics	Engineering Mechanics
	Foundations Design & Entrepreneurship 2	Foundations Design & Entrepreneurship 2	Foundations Design & Entrepreneurship 2
	Leadership Seminar 1*	Leadership Seminar 1*	Leadership Seminar 1*
	Applied Programming for Engineers*	Applied Programming for Engineers*	Applied Programming for Engineers*
Year 2			
Sem 1 Jan 2022– May 2022 Jan 2023–May 2023	Physics: Electromagnetism	Physics: Electromagnetism	Physics: Electromagnetism
	Applied Programming for Engineering	Applied Programming for Engineering	Applied Programming for Engineering
	Discrete Mathematics	CAD/CAM	CAD/CAM
	Data Structures & Algorithms	Thermodynamics	Thermodynamics
	Leadership Seminar 2*	Leadership Seminar 2*	Leadership Seminar 2*
Sem 2 Aug 2022- Dec2022 Aug 2023- Dec2023	Circuits and Electronics	Circuits and Electronics	Circuits and Electronics
	Materials Science & Chemistry	Materials Science & Chemistry	Materials Science & Chemistry
	Differential Equations & Numerical Methods	Differential Equations & Numerical Methods	Differential Equations & Numerical Methods
	Statistics for Engineering	Statistics for Engineering	Statistics for Engineering
	Text and Meaning	Text and Meaning	Text and Meaning
	Leadership Seminar 3*	Leadership Seminar 3*	Leadership Seminar 3*
Year 3			
Sem 1 Jan 2023– May 2023 Jan 2024–May 2024	Computer Organization & Architecture	Electrical Machines	Electrical Machines
	System Dynamics	System Dynamics	System Dynamics
	Signals & Systems	Signals & Systems	Mechanics of Materials
	Leadership Seminar 4 for Engineers (Includes Year 3 Group Project)	Leadership Seminar 4 for Engineers (Includes Year 3 Group Project)	Leadership Seminar 4 for Engineers (Includes Year 3 Group Project)
	Instrumentation for Engineering*	Instrumentation for Engineering*	Instrumentation for Engineering*
Sem 2 Aug 2023- Dec2023 Aug 2024- Dec2024	Control Systems	Control Systems	Control Systems
	Networks & Data Communications	Adv Electrical Machines & Power Elect	Mechanical Machine Design
	Digital Systems Design	Digital Systems Design	Fluid Mechanics
	Intermediate Computer Programming	Communication Systems	Manufacturing Processes
	Year 3 Group Project & Seminar*	Year 3 Group Project & Seminar*	Year 3 Group Project & Seminar*
Year 4			
Sem 1 Jan 2024– May 2024 Jan 2025–May 2025	Operating Systems	Power Engineering	Mechanics of Machines
	CE Elective	EE Elective	ME Elective
	Principles of Economics	Principles of Economics	Principles of Economics
	Embedded Systems	Embedded Systems	Heat Transfer
	Elective	Elective	Elective
Sem 2 Aug 2024- Dec2024 Aug 2025- Dec2025	Project Management and Professional Practice	Project Management and Professional Practice	Project Management and Professional Practice
	CE Elective	EE Elective	ME Elective
	African Studies Elective	African Studies Elective	Manufacturing Processes
	Senior Project & Seminar	Senior Project & Seminar	Senior Project & Seminar

EE Year 4: students wishing to do Networks should do Africana in Sem 1 and Networks in Sem II

CE: Year 4: if desiring to do a Sem II elective, consider doing Africana in Sem 1

PLANS OF STUDY PER YEAR, SEMESTER, and PROGRAM

Plan of Study: Business Administration

ASHESI UNIVERSITY Department of Business Administration			
BSc. Business Administration			
Ashesi Courses:			
Freshman Undergraduate	**Sophomore Undergraduate**	**Junior Undergraduate**	**Senior Undergraduate**
YEAR 1 **SEMESTER 1 & 2**	**YEAR 2** **SEMESTER 3 & 4**	**YEAR 3** **SEMESTER 5 & 6**	**YEAR 4** **SEMESTER 7 & 8**
PRE-MATRICULATION Entrepreneurship Universe Writing, Public Speaking and Multimedia Communication Creative Approaches to African Development Introduction to Computing and Information Systems Principles of Design Quantitative Estimation and Data Visualization **Optional Modules:** How to Communicate like a Leader Math Bridge English Bridge			
SEMESTER 1 • Ashesi Success • Pre-calculus 1 or Calculus 1 (4 credits) • Written & Oral Communication (4 credits) • Foundations of Design & Entrepreneurship 1 (4 credits) • Introduction to Computing and Information Systems (4 credits)	**SEMESTER 3** • Leadership Seminar 2 (2 credits) • Statistics (4 credits) • Microeconomics (4 credits) • Financial Accounting (4 credits) • Non- Major Elective (4 credits)	**SEMESTER 5** • Operations Management (4 credits) • Investments (4 credits) • International Trade & Policy (4 credits) • Leadership Seminar IV or Elective (4 credits)	**SEMESTER 7** • Corporate Finance (4 credits) • Business Law (4 credits) • Elective (4 credits) • Capstone 1 (4 credits or 4.5)
SEMESTER 2 • Leadership Seminar 1 (2 credits) • Precalculus 2 or Calculus 2 (4 credits) • Text and Meaning (4 credits) • Foundations of Design and Entrepreneurship II (4 credits) • Organizational Behavior (4 credits)	**SEMESTER 4** • Leadership Seminar 3 (2 credits) • Quantitative Methods (4 credits) • Macroeconomics (4 credits) • Marketing (4 credits) • Introduction to Finance (4 credits) **SUMMER** Applied Calculus (Pre-Calculus Students only)	**SEMESTER 6** • Research Methods (4 credits) • Managerial Accounting (4 credits) • Business Elective (4 credits) • Leadership Seminar IV or Elective (4 credits)	**SEMESTER 8** • Competitive Strategy (4 credits) • Elective (4 credits) • Elective (4 credits) • Capstone 2 (4 credits or 4.5)
Total Credits: 34-38	**Total Credits: 36**	**Total Credits: 28**	**Total Credits: 32**

Total Credits for BA Program = 134-139

Plan of Study: Computer Science

ASHESI UNIVERSITY
Department of Computer Science and Information Systems

BSc. Computer Science

Freshman Undergraduate	Sophomore Undergraduate	Junior Undergraduate	Senior Undergraduate
YEAR 1 **SEMESTER 1 & 2**	**YEAR 2** **SEMESTER 3 & 4**	**YEAR 3** **SEMESTER 5 & 6**	**YEAR 4** **SEMESTER 7 & 8**
PRE-MATRICULATION Entrepreneurship Universe Writing, Public Speaking and Multimedia Communication Creative Approaches to African Development Introduction to Computing and Information Systems Principles of Design Quantitative Estimation and Data Visualization **Optional Modules:** How to Communicate like a Leader Math Bridge English Bridge			
SEMESTER 1 • Ashesi Success (0 credits) • Pre-calculus 1 or Calculus 1 (4 credits) • Written & Oral Communication (4 credits) • Foundations of Design & Entrepreneurship 1 (4 credits) • Intro. To Computing & Information Systems (4 credits)	**SEMESTER 3** • Leadership Seminar 2 (2 credits) • Statistics (4 credits) • Principles of Economics (4 credits) • Discrete Structures & Theory (4 credits) • Object Oriented Programming (4 credits)	**SEMESTER 5** • Leadership Seminar 4 or Major Elective (4 credits) • Web Technologies (4 credits) • Algorithm Design & Analysis (4 credits) • Intermediate Computer Programming (4 credits) • Systems Fundamentals (2 credits)	**SEMESTER 7** • Operating Systems (4 credits) • Finance for non-Finance Managers (4 credits) • Elective (4 credits) • Capstone 1 (Undergraduate Thesis 1/ Entrepreneurship 1/ Extra major elective) (4 credits) • CSIS Capstone Seminar (0 credits)
SEMESTER 2 • Leadership 1 (2 credits) • Pre-calculus 2 or Calculus 2 (4 credits) • Text & Meaning (4 credits) • Foundations of Design & Entrepreneurship 2 (4 credits) • Computer Programing for CS (4 credits)	**SEMESTER 4** • Leadership Seminar 3 (2 credits) • Linear Algebra (4 credits) • Data Structures & Algorithms (4 credits) • Database Systems (4 credits) • Introduction to Artificial Intelligence (4 credits) **SUMMER** Applied Calculus (Pre-Calculus Students only)	**SEMESTER 6** • Leadership Seminar 4 or Elective (4 credits) • Software Engineering (4 credits) • Computer Organization & Architecture (4 credits) • Research Methods (4 credits) • Introduction to Modelling and Simulation (2 credits)	**SEMESTER 8** • Networks & Data Communications (4 credits) • Elective (4 credits) • Elective (4 credits) • Capstone 2 (Undergraduate Thesis 2/ Entrepreneurship 2/ Applied Project) (4 credits)
Total Credits: 34	**Total Credits: 36**	**Total Credits: 36**	**Total Credits: 32**

Total Credits for CS Program = 138

Plan of Study: Management Information Systems

ASHESI UNIVERSITY
Department of Computer Science and Information Systems

BSc. Management Information Systems

Freshman Undergraduate	Sophomore Undergraduate	Junior Undergraduate	Senior Undergraduate
YEAR 1 **SEMESTER 1 & 2**	**YEAR 2** **SEMESTER 3 & 4**	**YEAR 3** **SEMESTER 5 & 6**	**YEAR 4** **SEMESTER 7 & 8**
PRE-MATRICULATION Entrepreneurship Universe Writing, Public Speaking and Multimedia Communication Creative Approaches to African Development Introduction to Computing and Information Systems Principles of Design Quantitative Estimation and Data Visualization **Optional Modules:** How to Communicate like a Leader Math Bridge English Bridge			
SEMESTER 1 • Ashesi Success (0 credit) • Pre-calculus 1 or Calculus 1 (4 credits) • Written & Oral Communication (4 credits) • Foundations of Design & Entrepreneurship 1 (4 credits) • Intro. To Computing & Information Systems (4 credits)	**SEMESTER 3** • Leadership Seminar 2 (2 credits) • Statistics (4 credits) • Principles of Economics (4 credits) • Discrete Structures & Theory (4 credits) • Object Oriented Programming (4 credits)	**SEMESTER 5** • Leadership Seminar 4 or Major Elective (4 credits) • Web Technologies (4 credits) • Systems Analysis & Design (4 credits) • Finance for non-finance managers (4 credits)	**SEMESTER 7** • E-Commerce (4 credits) • Information and Systems Security (4 credits) • Elective (4 credits) • Capstone 1 (Entrepreneurship 1/Thesis 1/ Extra major elective) (4 credits)
SEMESTER 2 • Leadership Seminar 1 (2 credits) • Pre-calculus 2 or Calculus 2 (4 credits) • Text & Meaning (4 credits) • Foundations of Design & Entrepreneurship 2 (4 credits) • Computer Programming for CS (4 credits)	**SEMESTER 4** • Leadership Seminar 3 (2 credits) • Quantitative Methods (4 credits) • Database Systems (4 credits) • Introduction to Artificial Intelligence (4 credits) • Non-Major Elective or Data Structures (4 credits) **SUMMER** Applied Calculus (Pre-Calculus Students only)	**SEMESTER 6** • Leadership Seminar 4 or Major Elective (4 credits) • Research Methods (4 credits) • IT Infrastructure and Systems Administration (4 credit) • IS Project Management (4 credits)	**SEMESTER 8** • Competitive Strategy (4 credits) • Elective (4 credits) • Elective (4 credits) • Capstone 2 (Entrepreneurship 2/ Thesis 2/ Applied Project) (4 credits)
Total Credits: 34	**Total Credits: 36**	**Total Credits: 32**	**Total Credits: 32**

Total Credits for MIS Program = 134

Plan of Study: Computer Engineering

ASHESI UNIVERSITY (ASHESI)
Department of Engineering

BSc. Computer Engineering

Ashesi Courses:

Freshman Undergraduate	Sophomore Undergraduate	Junior Undergraduate	Senior Undergraduate
YEAR 1 **SEMESTER 1 & 2**	**YEAR 2** **SEMESTER 3 & 4**	**YEAR 3** **SEMESTER 5 & 6**	**YEAR 4** **SEMESTER 7 & 8**
PRE-MATRICULATION Entrepreneurship Universe Writing, Public Speaking and Multimedia Communication Creative Approaches to African Development Introduction to Computing and Information Systems Principles of Design Quantitative Estimation and Data Visualization **Optional Modules:** How to Communicate like a Leader Math Bridge for ENG English Bridge			
SEMESTER 1 • Ashesi Success (0 credit) • Calculus for Engineering (4 credits) • Written & Oral Communication (4 credits) • Foundations of Design & Entrepreneurship 1 (4 credits) • Introduction to Engineering (6 credits)	**SEMESTER 3** • Physics: Electromagnetism (6 credits) • Applied Programming for Engineers (2 credits) • Data Structures & Algorithm (4 credits) • Leadership Seminar 2 (2 credits)	**SEMESTER 5** • Computer Organization & Architecture (4.5 credits) • System Dynamics (6 credits) • Signals & Systems (6 credits) • Leadership Seminar 4 for Engineers (includes Year 3 Group Project) (4 credits) • Instrumentation for Engineering (2 credits)	**SEMESTER 7** • Operating System (6 credits) • CE Elective (4 credits) • Principles of Economics (4 credits • Embedded Systems (6 credits) • Electives (4 credits)
SEMESTER 2 • Computer Programming for Engineering (4 credits) • Multivariable Calculus & Linear Algebra (4 credits) • Physics: Mechanics (6 credits) • Foundations of Design & Entrepreneurship 2 (4 credits) • Leadership Seminar 1 (2 credits)	**SEMESTER 4** • Leadership Seminar 3 (2 credits) • Circuits and Electronics (6 credits) • Materials Science & Chemistry (6 credits) • Differential Equations & Numerical Methods (4 credits) • Text and Meaning (4 credits) • Statistics for Engineering (4 credits)	**SEMESTER 6** • Control Systems (6 credits) • Networks & Data Communications (6 credits) • Intermediate Computer Programming (4.5 credits) • Digital Systems Design (4.5 credits) • CE Electives (4 credits) • Year 3 Group Project & Seminar (2 credits)	**SEMESTER 8** • Project Management and Professional Practice (4 credits) • CE Elective (4 credits) • African Studies Elective (4 credits) • Senior Project & Seminar (4 credits)
Total Credits: 37	**Total Credits: 42**	**Total Credits: 41.5**	**Total Credits: 36**

Total Credits for Computer Engineering Program=136

Plan of Study: Electrical & Electronic Engineering

ASHESI UNIVERSITY (ASHESI) Department of Engineering			
BSc. Electrical Engineering			
Ashesi Courses:			
Freshman Undergraduate	**Sophomore Undergraduate**	**Junior Undergraduate**	**Senior Undergraduate**
YEAR 1 **SEMESTER 1 & 2**	**YEAR 2** **SEMESTER 3 & 4**	**YEAR 3** **SEMESTER 5 & 6**	**YEAR 4** **SEMESTER 7 & 8**
PRE-MATRICULATION Entrepreneurship Universe Writing, Public Speaking and Multimedia Communication Creative Approaches to African Development Introduction to Computing and Information Systems Principles of Design Quantitative Estimation and Data Visualization **Optional Modules:** How to Communicate like a Leader Math Bridge for ENG English Bridge			
SEMESTER 1 • Calculus for Engineering (4 credits) • Written & Oral Communication (4 credits) • Foundations of Design & Entrepreneurship 1 (4 credits) • Introduction to Engineering (4 credits)	**SEMESTER 3** • Physics Electromagnetism (6 credits) • Applied Programming for Engineers (2 credits) • CAD/CAM (4 credits) • Thermodynamics (6 credits) • Leadership Seminar 2 (2 credits)	**SEMESTER 5** • Electrical Machines (6 credits) • System Dynamics (6 credits) • Signals & Systems (6 credits) • Leadership 4 for Engineers (includes Year 3 Group Project) (4 credits) • Instrumentation for Engineers (2 credits	**SEMESTER 7** • Power Engineering (6 credits) • EE Elective (4 credits) • Principles of Economics (4 credits) • Embedded Systems (6 credits) • Elective (4 credits)
SEMESTER 2 • Computer Programming for Engineering (4 credits) • Multivariable Calculus & Linear Algebra (4 credits) • Engineering Mechanics (6 credits) • Foundations of Design & Entrepreneurship 2 (4 credits) • Leadership Seminar 1 (2 credits)	**SEMESTER 4** • Leadership Seminar 3 (2 credits) • Circuits & Electronics (6 credits) • Statistics for Engineers (4 credits) • Text and Meaning (4 credits) • Material Science & Chemistry (6 credits) • Differential Equations & Numerical Methods (4 credits)	**SEMESTER 6** • Control Systems (6 credits) • Adv Electrical Machines & Power Elect II OR Embedded Systems (6 credits) • Digital Systems Design (4.5 credits) • Communication Systems (4.5 credits) • Year 3 Group Project & Seminar (2 credits) • EE Elective (4 credits)	**SEMESTER 8** • Project Management and Professional Practice (4 credits) • EE Elective (4 credits) • African Studies Elective (4 credits) • Senior Project 2 & Seminar (4 credits)
Total Credits: 36	**Total Credits: 38**	**Total Credits: 46**	**Total Credits: 36**

Total Credits for Electrical Engineering Program=136

Plan of Study: Mechanical Engineering

ASHESI UNIVERSITY (ASHESI)
Department of Engineering

BSc. Mechanical Engineering

Ashesi Courses:

Freshman Undergraduate	Sophomore Undergraduate	Junior Undergraduate	Senior Undergraduate
YEAR 1 **SEMESTER 1 & 2**	**YEAR 2** **SEMESTER 3 & 4**	**YEAR 3** **SEMESTER 5 & 6**	**YEAR 4** **SEMESTER 7 & 8**
PRE-MATRICULATION Entrepreneurship Universe Writing, Public Speaking and Multimedia Communication Creative Approaches to African Development Introduction to Computing and Information Systems Principles of Design Quantitative Estimation and Data Visualization **Optional Modules:** How to communicate like a leader Math Bridge for ENG English Bridge			
SEMESTER 1 • Calculus for Engineering 1 (4 credits) • Written & Oral Communication (4 credits) • Foundations of Design & Entrepreneurship (4 credits) • Introduction to Engineering (6 credits)	**SEMESTER 3** • Physics: Electromagnetism (6 credits) • Applied Programming for Engineers (2 credits) • CAD/CAM (4 credits) • Thermodynamics (6 credits) • Leadership Seminar 2 (2 credits)	**SEMESTER 5** • Electrical Machines (6 credits) • System Dynamics (6 credits) • Mechanics of Materials (6 credits) • Leadership 4 for Engineers (Includes Year 3 Group Projects) (4 credits) • Instrumentation for Engineering (2 credits)	**SEMESTER 7** • Mechanics of Machines (6 credits) • ME Elective (4 credits) • Principles of Economics (4 credits) • Heat Transfer (6 credits) • Elective (4 units)
SEMESTER 2 • Computer Programming for Engineering (4.5 credits) • Multivariable Calculus & Linear Algebra (4 credits) • Engineering Mechanics (6 Credits) • Foundations of Design & Entrepreneurship 2 (4 credits) • Leadership Seminar 1 (2 credits)	**SEMESTER 4** • Leadership Seminar 3 (2 credits) • Circuits & Electronics (6 credits) • Material Science & Chemistry (6 credits) • Differential Equations & Numerical Methods (4 credits) • Statistics for Engineering (4 credits) • Text and Meaning (4 credits)	**SEMESTER 6** • Control Systems (6 credits) • Mechanical Machine Design (6 credits) • Fluid Mechanics (6 credits) • Manufacturing Processes (6 credits) • Year 3 Group Project & Seminar (2 credits) • ME Elective (4 credits)	**SEMESTER 8** • Project Management & Professional Practice (4 credits) • ME Elective (4 credits) • Manufacturing Processes (6 credits) • Senior Project 2 & Seminar (4 credits)
Total Credits: 37.5	**Total Credits: 46**	**Total Credits: 54**	**Total Credits: 42**

Total Credits for ME Program = 179.5

DESCRIPTIONS OF COURSES and PREREQUISITES

Business Administration

BUSA 001 Entrepreneurship Universe
Required for Freshman Students
Prerequisite: none
Offered: Fall
Course Type: Lecture, Seminar, Experiential
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Entrepreneurship Universe is a four-week introductory overview of the entrepreneurial discipline. The module will take students on an exciting journey of understanding and connecting dots in selected domains of entrepreneurship as deemed relevant. Specific aspects to be covered will include definition and evolution of entrepreneurship, the role of entrepreneurship in economic development, forms of entrepreneurial endeavors, myths of entrepreneurship, key characteristics of entrepreneurs, what the entrepreneurship process entails within and outside our context, among others.

BUSA 100 Principles of Economics
Required for all CS & ENG Majors
Prerequisite: Pre-Calculus 2 or Calculus 1
Offered: Fall
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Welcome to Principles of Economics. This course is an exciting introduction to the field of economics, with application to the local context. Economics has two main divisions: microeconomics and macroeconomics. We will first tackle the microeconomics topics and then move on to the macroeconomics topics, but both set of topics are equally pertinent. After a general introduction to the field of economics and explaining the difference between microeconomics and macroeconomics, the course will start by delving into microeconomic theory before finishing up with macroeconomics theory.

Traditional microeconomic topics that will be treated include the concept of the invisible hand and the role of incentives in the market; supply and demand; international trade; elasticity; taxation, and the implications of government policy for individual firms. For the section on macroeconomics, we will discuss simple models of goods and services, assets, capital, and labor markets, which can be usefully applied to generate realistic predictions regarding the behavior of such macroeconomic variables as output and growth; employment; inflation; the current account; as well as interest and exchange rates. The course will teach students to use these models to understand and interpret current and historical macroeconomic developments. Current macroeconomic developments and policy changes, such as the effects of the COVID-19 pandemic, global inflation related to rising oil prices and the geopolitical conflict between Russia and Ukraine, and possible impacts of national debt and corruption on macroeconomic stability and performance of African countries like Ghana, will be discussed. The role of the IMF in helping countries to manage economic challenges will be assessed.

BUSA 132 Organizational Behavior
Required for all BA Majors
Prerequisite: None
Offered: Typically taught in Fall

Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hour of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

How can managers motivate employees to go above the call of duty to get the job done? How can managers be sure their decisions are not biased? What influence tactics can managers use when they do not have formal authority to tell someone what to do? This course will help students understand life in complex organizations by covering topics that span microanalysis dealing with individuals and macro analysis dealing with the organization. The course is managerial in orientation and focuses on the processes necessary to organize, motivate, direct and control people engaged in collective activities. The emphasis is on the development of concepts and strategies that will help students become managers that are more effective. The course uses readings, cases, exercises and videos to illustrate the conceptual and applied aspects of individual, group and organizational behavior.

BUSA 161/A Foundation of Design & Entrepreneurship I
Required for all Ashesi Students
Prerequisite: none
Offered: Fall
Course Type: Lecture, Experiential
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This is the first part of a yearlong course on design and entrepreneurship. The goal of the course is to immerse all first-year students of the University, irrespective of major, into the world of design thinking, entrepreneurship and business management. For this semester's work, the course will cover two main aspects: design thinking for problem solving and entrepreneurial opportunity analysis. The two areas will involve students undertaking exercises to help hone their skills in design thinking, conduct business opportunity identification and analysis culminating in business concepts. Students will then develop and validate their business concepts and present them for evaluation. The first half of this semester will look at creativity, design thinking and innovation with the aim of positioning students to develop an innovative posture. Class sessions and activities will see students uncovering how the brain creates and prevents creativity, how to reframe problems, conduct research, conduct sensemaking to uncover insights from research, develop a point of view, ideate, prototype and develop solutions to the problems identified. The key focus areas are teaching them how to deal with ambiguity and be innovative and creative, in the midst of limitations and constraints. Students will also learn how to prototype and test their ideas with users. The second half of the semester will be structured to help students evaluate their design proposals and decide on how to take them further. Building on the background from the design module, students will study business opportunity analysis and business model development as entrepreneurs and intrapreneurs. They will run through the theories of business venture modelling to help them model their business concepts. This will serve as a basis for using tools like the business model canvas, which will require that students identify potential customer segments, develop and test value propositions that address their pain points, problems or needs they discovered in the first part of the course. At the end of the semester, students will reflect on the course, as well as present their business concepts for evaluation and selection for the business simulation project in the second semester.

BUSA 162 Foundation of Design & Entrepreneurship II
Required for all Ashesi Students
Prerequisite: FDE 1
Offered: Spring

Course Type: Lecture, Experiential
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This course is a continuation of Foundations of Design and Entrepreneurship (FDE) I and aims to build on the work done through business simulations on the solution concepts developed. The venture teams will start the semester with continued prototyping, developing, and testing their Minimum Viable Products (MVP), launching their venture concept, and running post-launch promotions, all the while learning about the key entrepreneurship concepts that pertain to the various activities performed in this course. However, the venture teams will not be registered legal entities during the period of the class (perhaps afterwards). Hence, we refer to the nature of the business the venture team conducts during the semester as a business simulation. To elaborate on the process, by conducting Customer Discovery, Customer Validation and exploring Customer Creation and Company Building hypothetically, FDE II teams can test and update their business concepts into validated business ideas that can potentially be explored post FDE. The testing process is iterative as teams will need to incorporate new information or pivot based on outcomes from testing in the rather continuous customer development process. Such informed customer discovery, validation and creation activities will reveal the viability of the business concept and therefore help the team determine if a business concept has prospects for company building or not by the end of the semester. The simulation process therefore provides a rigorous experiential learning corridor through which FDE teams encounter, experience, and process relevant business knowledge for business venturing in entrepreneurship (as well as in intrapreneurship at the corporate level). Towards the end of the semester, students will be guided in determining how they will transition out of the FDE program after two semesters. If they determine that their business venture should go into the Company Building phase, they will have the opportunity to enroll in the student led Ashesi Start-up Launchpad. If they decide that they are not interested in pursuing the venture, the team will be assisted in exiting the simulation, resolving inventory, and closing the books.

BUSA 210 Financial Accounting
Required for all BA Majors
Prerequisite: none
Offered: Fall or Summer
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This is an introductory accounting course that exposes students to fundamental accounting principles, the regulatory framework of accounting practice, elements of financial statements, the mechanics of data entry, preparation of financial statements, financial statement analysis, control accounts and reconciliations, and ethics in the accounting profession. The course is designed to provide students with the requisite skills for analyzing transactions, opening, and maintaining proper books of accounts, doing basic reconciliations, preparing financial statements for sole proprietorships, applying fundamental accounting principles and ethical codes in solving accounting and business problems, and evaluating the financial performance of a business entity using financial statement analysis.

BUSA 220 Introduction to Finance
Required for all BA Majors
Prerequisite: Financial Accounting
Offered: Spring or Summer
Course Type: Lecture

Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This is an introductory course aimed at equipping students with the basic skills of corporate finance. In this course, students will be introduced to some fundamental principles of corporate finance such as time value of money and risk. Specific areas of concentration include the time value of money, investment valuation and decision making under conditions of certainty and uncertainty, working capital management, capital budgeting, cost of capital, capital structure and dividend policy, and intermediate and long-term financing.

BUSA 224 Finance for non-Finance
Required for all MIS & CS Majors
Prerequisite: Pre-calculus 1 & 2 or Calculus 1; Prior or concurrent enrolment in Microeconomics
Offered: Spring & Summer
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This course is designed to equip students with the necessary tools, skills and competencies required of contemporary managers of top-notch organizations to properly handle financial management and planning issues. It is a platitude that almost every activity in an organization has some monetary implications, hence may translate into numbers. Managers must therefore be trained to know how their actions and inactions affects the numbers, which in turn affect the entity's profitability, a critical ingredient necessary for the long-term survival of the business.

The contents of the course are organised around four themes. The topics under the first theme covers the formation and organisation of businesses, tax compliance and planning, and participation in the financial markets in line with statutory regulations and best practices. Topics under the second theme covers the elements and components of general-purpose financial statements and evaluation of financial performance using financial statements analysis. Topics under the third theme covers cost classification and estimation, volume planning, and profit planning. Topics under the fourth theme covers valuation concepts, risk-return profile of investments, and financial appraisal of capital projects.

The course will be delivered through lectures on key concepts, spreadsheet practicums for selected applications, and presentation of relevant cases and current developments. The last discussion introduces the students to issues in sustainable and responsible investment (SRI). This discussion will centre around the evolution of SRI, concepts, and principles. Other topics include long-term investment and corporate social responsibility, sustainable development Goals and the Millennium Development Goals.

BUSA 304 Operations Management
Required for all BA Majors
Prerequisite: Quantitative Methods or Statistics for Engineering & Economics
Offered: Fall
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The study of Operations Management is an exciting area of management that has a profound effect on the productivity of both manufacturing and services. The goal of this course is to present a broad introduction in the field of operations in a realistic and practical manner.

When companies produce and deliver goods or services to meet customer demand, they do so by managing operations, in other words by executing business processes. In this course, students discover how business processes can be designed, analyzed and improved to lift the performance of any organization, whether it is a bank, a hospital, a resort, or a fashion retailer. The course reveals how process management skills can be used to reduce costs, lower inventories, cut waiting times, improve quality, enhance service levels, and increase revenues and company profits. Specifically, students will gain practical knowledge of process design, demand forecasting, capacity planning, workflow planning and control, quality management, and lean operations. With a focus on the basic concepts that govern process management, the course also provides the necessary foundation to pursue further development in operations and supply chain management.

Organizations need to understand how the various processes fit together, what the implications are for the weakest part of the process, identify opportunities for continuous improvement and also see from a bird's eye view, the approach leadership must take to ensure profitability, growth, continuous improvement, development of employees and sustainability. Throughout this course, you will also see learning outcomes in each unit. You can use those learning outcomes to help organize your studies and gauge your progress.

While looking out for all the above factors, there is also the issue of ensuring that the organization, institution or company is here for the long haul through a consistent review of sustainability requirements.

BUSA 311 Managerial Accounting
Required for all BA & MIS Majors
Prerequisite: Financial Accounting or Finance for non-Finance Managers
Offered: Spring or Summer
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The overall emphasis of this course is the use of accounting data within an organization by its managers. Managers need information to carry out three essential functions:

(1) Planning operations (2) controlling activities and (3) making decisions.

The purpose of this course is to show what kind of information is needed, where this information can be obtained, and how managers can use information as they carry out their planning, control, and decision-making responsibilities. The course also explains why managerial accounting is important to the future careers of all business students. It answers two questions. Topics that will be addressed in the course are cost accumulation methods for product costing; cost structure for control and motivation; cost-volume-profit relationships; profit planning and budgeting; standard costing; and relevant costs for non-routine decisions. Current and best practices will be discussed to provide you with the most recent information on how businesses accumulate and use the cost information.

BUSA 321 Investments
Required for all BA Majors
Prerequisite: Introduction to Finance or Finance for non-Finance Managers
Offered: Fall or Summer
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This course surveys the investment media, concepts, and techniques to provide an understanding of the investment process in the economic and financial environment. The course covers the elements of investments, portfolio theory and management, security analysis, valuation of stocks and bonds, and risk-return trade-off. The course entails only the necessary mathematical and technical details which will provide the intuition that may illuminate the gliding path for students as they confront new ideas and challenges in their later lives as investment practitioners. On the conviction that theories such as the capital asset pricing model and the efficient market hypothesis are intellectually satisfying subjects of scientific research as they are important building blocks for the development of solid grounding in investments, aspects of these theories will be used generously to determine the value of real and financial assets. As the instructor tries to bridge the gap between theory and practice, several real-world examples are presented. The course will consist of lectures and discussions of contemporary investment and finance challenges and developments in Ghana and across the globe. Students will be exposed to trends in socially responsible investing around the globe and what lessons Ghanaian Fund Managers can take. A good dose of data will be used in the 'analysis' part of the course. Students will be required to use Microsoft Excel analytic tools to solve a large part of the problem sets. This is also intended to provide students with a taste of tools they will need to understand and use in their career as investment analysts.

BUSA 341 Marketing
Required for all BA Majors
Prerequisite: Micro-economics
Offered: Spring
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1. Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Organizations, whether private, public or non-governmental have goals and objectives they seek to achieve. The level of success of these organizations and their long-term existence depends on their ability to effectively satisfy the needs of their customers, clients or stakeholders continually. The business environment in which organizations operate is changing rapidly and especially digital technology is permeating almost every aspect of human experience. The development of the Internet, World Wide Web and other digital technologies is changing the way business is done. Customers have much wider variety and prices from many more suppliers and more convenient ways of accessing products and services. The Covid-19 pandemic of 2020 has also brought about changes in consumers' habits and attitudes in ways such as how they shop, products they prioritize and how they interact with others.

The essential or big question this course seeks to answer is: "How do organizations create value for customers, clients and stakeholders while achieving the objectives of the organizations in a dynamic business environment where digital technology is increasingly pervasive, and the Covid-19 pandemic is transforming consumer behavior?" Students will be exposed to and have the opportunity to apply foundational knowledge of marketing concepts and principles, and skills that thriving firms or organizations use to undertake the following critical tasks that address the essential question posed above.

BUSA 350 International Trade & Policy
Required for all BA Majors
Prerequisite: Pre-calculus 1; Micro-Economics; Macro-Economics; Statistics
Offered: Spring
Course Type: Lecture

Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The course is designed to introduce students to the main concepts and methods of international trade using applications drawn from the real world. Throughout the course, we would convey the major ideas that have emerged from recent research while emphasizing the continued importance of the old theories. Throughout this course, the objective is to guide students to understand how the evolution of international economic theory has helped shape our understanding of a rapidly changing global economy. Also, how we can use the knowledge about international trade to contribute to the on-going debate about trade protection, free trade, regionalism and trade preferences among other issues.

BUSA 400A_B Thesis 1 & 2
Capstone option for BA, MIS, CS
Prerequisite: 8 Credits in Major Area of Study
Offered: Fall & Spring
Course Type: Seminar
Ashesi Units: 1; Credit Hours: 3; Hours per week classroom: 1.5; Hours per week discussion: N/A Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 10 per week)

The thesis capstone integrates the knowledge gained and skills acquired during a student's enrolment in the Business Administration department.

Students register for the thesis in both semesters of their fourth year. Each student enrolled on the thesis course will work independently on a research idea in an area of business studies. The research will be supervised by a member of faculty. The thesis should be viewed as an opportunity to understand complex questions from diverse business perspectives. This requires using appropriate theories and research methodology to continue Ashesi's active engagement with the community (both local and global).

Send an e-mail to sagbodjah@ashesi.edu.gh if you need further information on the BA Thesis capstone process.

BUSA 401_A Entrepreneurship 1
Capstone option for BA, MIS, CS
Prerequisite: 8 Credits in Major Area of Study
Offered: Fall
Course Type: Seminar, Experiential
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1. Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Entrepreneurship has been held by many as the key to development in the underdeveloped world. This is because it holds the potential of aiding problem solving through the development of innovative products and services. These will also help in reducing unemployment by serving as income generation avenues for the youth. If Africa, and indeed other developing economies, can achieve the Sustainable Development Goals (SDG), there will be the need to develop profit generating enterprises as well as social enterprises to serve as the backbone and propellant.

This capstone session, in a bid to further position Ashesi graduates to understand the nuances of start-ups and the entrepreneurial mindset to develop into entrepreneurs and intrapreneurs, integrates the skills and knowledge obtained from courses offered in the past three years of the student's education on campus. It will teach students what a start-up is and make the clear distinction between a start-up and a small business. It will take students through opportunity analysis and the development of sustainable

business models using Eric Ries' *Lean Startup*, Steve Blank's *Customer Development Process* and Alexander Osterwalder's *Business Model Canvas*.

The core teaching philosophy is experiential, learner-centric and inquiry-based to develop the mind-set, reflexes, agility and resilience an entrepreneur needs to search for certainty in the chaotic world of start-ups. This will be achieved with the adoption of several teaching aids and stress on the need to *get out of the classroom* to bring their businesses to life.

BUSA 401_B Entrepreneurship 2
Capstone option for BA, MIS, CS
Prerequisite: Entrepreneurship 1
Offered: Spring
Course Type: Seminar, Experiential
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Capstone Entrepreneurship II will aim to aid venture teams validate their business models by undertaking further customer and stakeholder engagements, as well as MVP tests. This will help the teams further validate their product-market fit and gain some early adopters/ earlyvangelists to patronize their products/ services and pay for them. Feedback from these earlyvangelists will inform further iterations and pivots. Venture teams will then be taken through the Customer Creation and Company Building aspects of the Customer Development process. These form the execution aspect of the Customer Development process. The student will look at their product/ service positioning considering the market type they are entering, plan to launch their venture or its product/ service and validate the triple bottom line of their business ventures. Due to time constraints, strategies for reaching mainstream customers and company building, with a focus on structuring fast response departments will be put in place to aid in executing this business model but may not be executed as a requirement of this session. Specifics include venture ownership, resource management, operations, and some management and cultural issues. A session will also be dedicated to family business related conversations to get students whose families own businesses, to understand the nuance and peculiarity of family businesses, and how they can navigate those spaces while acting as intrapreneurs.

At the end of the semester, venture teams will feed all this information into the traditional business plan format, which will be submitted to the Department. Additionally, they will pitch their businesses to a panel of experts for evaluation and feedback. They will also write an individual reflection paper on their entrepreneurial journey to ensure that they reflect on this year long Capstone experience. Instructors will also learn from this reflection to inform future capstone sessions.

BUSA 402 Business Law
Required for all BA Majors
Prerequisite: none
Offered: Fall
Course Type: Lecture, Experiential
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The topics in this course are intended to give you an in-depth knowledge of the legal framework relevant to the business environment in Ghana. Topics in this course include an Introduction to Sources of Law, the Law of Contract, the law relating to sale of goods, company law, torts in business, introduction aspects of employment law and dispute resolution.

The goal of this course is to familiarize you with the legal environment within which business is conducted in Ghana and Internationally. The course is not meant to train you to become lawyers. However, the basis of all business activity is underlined by rules and regulations and for that matter, laws.

It is therefore essential that as a student studying business law, you would comprehend rudiments or have a basic understanding of the legal framework governing businesses in Ghana.

BUSA 405 Competitive Strategy
Required for all BA & MIS Majors
Prerequisite: Introduction to Finance or Finance for non-Finance Managers; Macroeconomics; Prior or concurrent enrollment in Marketing recommended but not required.
Offered: Spring
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Organizations have always had to find ways to stay in business and, more importantly, thrive in their chosen markets. This goal requires the development, implementation and evaluation of business strategy. Competitive Strategy, also known as business strategy, is designed to establish a profitable and sustainable advantage and position for a business in a preferred marketplace. Although knowledge from such disciplines as Marketing and Human Resource Management is vital in managing a business, this course will focus on competition's role in business strategy development and implementation. Strategy development entails understanding the organization and competitive environ-ment in which a firm operates, formulating long-term direction, determining how to position a business unit, and creating a sustainable competitive advantage within a competitive environment. Strategy implementation or execution requires mobilizing resources, developing capabilities to compete, deploying the strategy, and reviewing performance as the business pursues its aspirations.

In Competitive Strategy, the role of the Strategist is to understand and cope with competition. The overall purpose of this course is to equip students to become strategists and high performing business executives by enhancing their ability to make and execute strategic business decisions in a competitive environment by:

*Understanding competition: acquire relevant tools to analyse the business and competitive environment

*Cope with competition: acquire knowledge, skills, traits and mindsets to craft and implement a winning strategy in a competitive environment.

Students will assume the role of general managers and business teams who have the overall responsibility for the performance of a business unit within a firm. The course is modelled around the classic work of Michael Porter and will be made relevant to modern times by using examples from recent experiences of companies. The class will also explore new thinking, ideas, and frameworks in business strategy. The course will allow students to practice and develop skills and mindsets to analyze a competitive environment (i.e., business environment, industry, and company), craft strategy and evaluate own and other practitioners' approaches to strategy and work.

The course will emphasize student-centered learning. The learning activities will include case analysis, discussions, debates, presentations, group projects, interaction with business executives and practitioners and lectures. We will use a "flipped" classroom where students will read relevant texts and prepare assigned case studies ahead of class. The class sessions will be devoted to discussing and clarifying issues and relating concepts, principles and theories to cases.

BUSA 410 Applied Project
Capstone option for BA, MIS, CS
Prerequisite: 8 Credits in Major Area of Study
Offered: Fall & Spring
Course Type: Seminar
Ashesi Units: 1; Credit Hours:3; Hours per week classroom: 1.5; Hours per week discussion: n/a Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 10 per week)

The Applied Project is characterized by its engagement with a real-life organization. Ultimately, students are expected to integrate foundational knowledge and skills gained over time and use them to solve real-life challenges for existing organizations. The successful execution of an Applied Project requires skill sets including research and critical analysis, stakeholder engagement, project management, professionalism, and communication. The benefits of an Applied Project are immense. It offers students the unique opportunity to immerse themselves in an organization and gain an understanding of business problems, relationships, and solutions. It also positions students to add value to the organization in the capacity of a junior consultant. Once the project is successfully accomplished, it becomes a strong addition to the student's personal and professional track record, and will certainly open many doors for referrals, internship, and job opportunities. It also provides the student with insights regarding what to pursue in the area of postgraduate studies. Send an email to sagbodjah@ashesi.edu.gh if you have any questions about the BA Applied Project.

BUSA 422 Corporate Finance
Required for all BA Majors
Prerequisite: Investments Offered: Spring & Summer
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This course covers numerous issues of practical relevance to the contemporary corporate finance manager. Although the central focus will be on how corporations make investment and financing decisions, the introductory classes will discuss households' saving and investment decision-making and how securities markets and financial intermediaries complement such efforts. Topics to be covered include risk and return, asset valuation, working capital management, mergers and acquisitions, and corporate restructuring. The course focuses on the application of corporate finance concepts to solving real life problems in a typical business environment. Students will learn to appreciate how the timing of and uncertainty about future cash flows and their associated risks combine to determine the current value of those cash flows. It is expected that assignments, class projects, and discussions will provide the needed motivation and enhance students' understanding of the finance theories to be discussed. The numerous real-life examples and cases are aimed at equipping the students with skills to plug-and-play in a starting finance position in any organization in Ghana and abroad.

BUSA 423 International Finance
Major Elective for BA, MIS. Non-Major Elective for ENG and CS
Prerequisite: Introduction to Finance
Offered: Typically offered in the Spring
Course Type: Lecture, Experiential
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The course aims at providing students with a basic understanding of the international financial market, and multinational finance and investment environment. This course extends the basic principles of corporate finance to dimensions peculiar to global financial markets and multinational corporations. It is designed to cover areas of international finance such as the international financial markets, international parity conditions, foreign exchange determination and quotations, derivative securities for currency risk management, and management of the risk of multinational operations. Thus, beside the discussion of issues of corporate finance such as working capital management, capital budgeting, risk and returns, and cost of capital from the perspective of multinational enterprises, additional issues such as international monetary system, currency derivatives, exchange rate changes and regimes, and political risk are also covered.

BUSA 430 Human Resource Management
Major Elective for BA, MIS. Non-Major Elective for ENG and CS Prerequisite: Organizational behavior
Offered: Typically offered in the Fall
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The purpose of this course is to familiarize you with the basic principles and techniques of human resource management. The course takes a practical view that incorporates the contributions of the behavioral sciences with the technical aspects of implementing the HR function in the 'real world.'

Surely, not everyone who takes this course will become a human resource professional, although that individual will learn a great deal about those roles. However, all managers, no matter what their specializations are, play essential roles in carrying out HR policies and practices in their organizations. Consequently, a basic understanding of human resource management (HRM) is essential wherever you find yourself in your world of work. The key objective of this course is to enable you learn that HRM is more than just accepting employment applications and keeping records. It is a central and strategic organizational activity of increasing complexity and importance.

BUSA 431 Real Estate Development
Major Elective for BA, MIS. Non-Major Elective for ENG and CS
Prerequisite: Quantitative Methods or Statistics for Engineering & Economics
Offered: Typically offered in the Fall
Course Type: Lecture, Experiential
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The real estate development course aims to introduce students to what real estate development (RED) is and what the development process entails. It seeks to provide students with a good overview of what goes into the various stages of the development process with emphasis on feasibility studies, financing and management.

The class will undertake a feasibility study for a real-life client. This client needs a feasibility study conducted for a development they want to embark on. The outputs expected are a feasibility report and recommendations for financing and property management, post development. Students in the class will be split into teams to conduct the study, going through the 8-stages of the development process. They will do this as they are taken through the various stages of development process in the class, visit the site and also interact with professionals who will help them make development and investment decisions for

the client. The bottom line is a development which is sustainable where its financial model is concerned, and one that is environmentally considerate.

Students will as well engage with different persons (guest lecturers) on their experiences on different developments (Public and private). As well, class tasks will have students explore developments across the continents to learn from their successes and challenges. This task will involve an assessment of the sustainability of the developments.

It is the hope of the instructors of this class that students will enjoy working on this live case, and in the process, develop skills to benefit future interest in the industry as well as in conducting marketing and feasibility studies.

BUSA 442 Strategic Brand Management
Major Elective for BA, MIS. Non-Major Elective for ENG and CS
Prerequisite: Marketing and Text & Meaning; or Foundations of Design & Entrepreneurship II Offered: Typically offered in the Fall
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The tremendous economic growth and development that the world has experienced in recent decades before the Covid-19 pandemic in 2020 have meant individuals and business managers in most countries are inundated with a wide variety of products and services from which to choose. For the individual, finding time to select from a wide variety of products and services may be challenging, but more products and services on the market mean stiffer competition for the firm. A growing number of firms and organizations have realized that one of their most valuable assets is the brand names associated with their products or services.

The exponential rate of mobile telephony growth, growing internet access, and social media use are giving greater power and voice to consumers and other stakeholders at the expense of businesses and brand managers. Brand Managers' ability to simplify the consumer decision-making process, reduce risks, set expectations, and set apart their brands from their competitors' brands is invaluable. Creating strong brands that deliver on their promise and maintaining and enhancing those brands' strength over time is imperative for business success but rather daunting.

Additionally, it has become imperative for higher education institutions that offer strategic brand management courses to include Environmental, Social, and Governance (ESG) and sustainability elements in their curriculum due to the nature of the contemporary marketplace. Firstly, ESG and sustainability are becoming increasingly important for companies and central to brand strategy and reputation. Including these elements in brand management education ensures that students are ready for the business world's demands and the challenges they may encounter in their careers. Secondly, business practices can significantly impact society and the environment, and incorporating ESG and sustainability into brand management education allows students to understand the role of business in promoting sustainability and the importance of responsible practices. Additionally, there is growing demand from consumers, investors, and employees for companies to prioritize ESG and sustainability, so companies need employees who are trained in these considerations. By including ESG and sustainability in brand management education, students are better equipped to meet this demand and contribute to their companies' success. The business landscape is rapidly changing, and ESG and sustainability will continue to play a crucial role in shaping its future. Including these elements in brand management education ensures that students have the necessary skills and knowledge to succeed in the future. In conclusion, incorporating ESG and sustainability into a strategic brand management curriculum prepares students for

the opportunities and challenges of the business world and helps them understand the role of business in promoting sustainability and responsible practices.

BUSA 444 Supply Chain Management
Major Elective for BA, MIS. Non-Major Elective for ENG and CS
Prerequisite: Quantitative Methods; or Statistics for Engineering & Principles of Economics
Offered: Typically offered in the Fall
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This course presents the fundamental concepts and tools needed to understand how Supply Chains work. The content spans the typical scope of supply chains: Plan, Source, Make, Deliver and Sell set in today's global market in which there is fierce competition, more frequent innovation and more sophisticated and demanding customers/consumers. Continuous advances in technology also provide a wide variety of continuous improvement options in supply chains. The interactions of the factors and levels of supply chains are explored for optimization and efficiency in Supply Management, Inventory Management, Product & Production Management, Distribution and Transportation Management. The Course also covers Responsible Sourcing and the Key Performance Indices that are used to determine service levels and efficiencies in supply chains.

BUSA 451 Development Economics
Major Elective for BA, MIS. Non-Major Elective for ENG and CS
Prerequisite: Micro-economics or Macro-Economics or Principles of Economics; and Statistics
Offered: Typically offered in the Fall
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Why do countries with low average incomes have peculiar and similar problems such as severe inflation, corruption, balance of payment and debt problems, overpopulation & teenage pregnancy, slums, poor governance, and weak institutions. What can be done about this? How did Singapore, Hong-Kong, South Korea, and Taiwan (the Asian Tigers), China, Qatar, Ireland etc. become so rich recently even though they were not so rich half a century ago and were in situations not too dissimilar from African countries at the time.

This course discusses the problems faced by Least Developed Countries (LDCs) and Lower Middle-Income countries (in Africa, Asia, and Latin America) and their efforts to improve the lives and well-being of their people. It incorporates different aspects of the development process including traditional development topics like economic growth, education, population studies, migration and rural-urban migration, and poverty as well as less traditional but equally pertinent topics like economic and political institutions, competition policy & antitrust laws, foreign aid, culture, leadership, and corruption. The course starts with a synthesis of the history of the models of economic development with growth models as a particular strand of the development theories and models. The course also includes activities that presents opportunities for students to delve into the inter-relationship between culture, corruption, and debt challenges both as a development challenge and to address the Ashesi Learning Goal of Ethics & Civic Engagement.

ECON 101 Micro-Economics

Required for all BA, MIS Majors. CS & ENG majors can substitute Principles of Economics with this course.
Prerequisite: Pre-Calculus 2 or Calculus 1
Offered: Fall or Summer
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This course will cover the principles of microeconomic analysis with the aim of helping students make better business decisions in their professional careers. In addition to introducing the standard basis of economic theory such as perfect information, production theory, perfect competition and imperfect competition, the course will focus on helping students think strategically about achieving competitive advantage through the management of the firm's resources. Through this course, students will develop an understanding of basic microeconomic theory and improve their ability to make sound business decisions.

ECON 102 Macro-Economics
Required for all BA & MIS majors Prerequisite: Pre-Calculus 2 or Calculus 1
Offered: Spring or Summer
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Welcome to Principles of Macroeconomics at Ashesi University. This is an exciting time to be taking be taking this course because the course is an introduction to macroeconomics, with application to the local context. Ashesi University is in Berekuso in Ghana, West Africa, and the economies of West African countries like Ghana are in flux due to local macroeconomic management challenges at the local level and global forces both related and unrelated to the Global COVID 19 pandemic.

The Principles of Macroeconomics Course at Ashesi has two objectives. First, the course will develop simple models of goods and services, assets, capital, and labour markets which can be usefully applied to generate realistic predictions regarding the behaviour of such macroeconomic variables as: output; employment; inflation; the current account; as well as interest and exchange rates. Secondly, the course will teach students to use these models to understand and interpret contemporary and historical macroeconomic developments. Current macroeconomic developments and policy challenges such as the effects of the COVID 19 pandemic, global inflation related to geopolitical conflict between Russia and Ukraine, and rising oil global prices of oil, as well as local inflation due to global forces and possible impacts of national debt and corruption on macroeconomic stability will be discussed. The role of the IMF in helping developing countries like Ghana to manage economic challenges will be assessed.

ECON 452 Econometrics
Major Elective for BA, MIS. Non-Major Elective for ENG and CS
Prerequisite: Micro-economics or Macro-Economics or Principles of Economics; and Statistics and Quantitative Methods (Multi Variable Calculus can replace Quant Methods as a prerequisite for this class)
Offered: Typically offered in the Fall
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The objectives of the course are the following:

- Introduce students to techniques for performing statistical analysis on quantitative data focusing on the estimation of the regression model.
- Help students solve problems commonly encountered in estimating statistical models like the regression model.
- Teach students to interpret the estimates from such models.
- Enable students to be able to perform quantitative analysis using secondary data.

Please note: The course is ideal for current Ashesi seniors and juniors interested in the analysis of quantitative (as opposed to qualitative) data.

ECON 455 Managerial Economics
Major Elective for BA, MIS. Non-Major Elective for ENG and CS
Prerequisite: Calculus 2 or Applied Calculus; Micro-economics; Macro-economics; Statistics or Econometrics
Offered: Typically offered in the Spring
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Managerial Economics is the study of the different ways in which economic principles and quantitative tools can be employed to assist managers to make effective decisions. It provides principles to foster the attainment of the goals of the organization, as well as engineer a better understanding of the external business environment in which an organization operates. The course enhances students' understanding of how markets operate and develops their capability to make economic predictions about market outcomes in order to take effective decisions to maximize profit and firm value.

ENGR 413 Project Management & Professional Practice
Major Elective for BA, MIS. Non-Major Elective for ENG and CS
Prerequisite: Operations Management
Offered: Typically offered in the Fall
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Projects occur in our daily lives, whether it be a simple task of taking a shower to complex tasks, such as sending a space craft to Mars. The process, though similar, will require different degrees of planning, and resource requirements to deliver as they have different scopes and outcomes, and as well influence a different set of stakeholders with specific requirements. It is thus imperative, that every person knows the basics of project management to manage the various projects that they undertake in their daily lives. More so as students, who undertake various class and social projects, while preparing to join the world of work (filled with projects) in the very near future, acquiring good project management skills within the structured framework positions one to get certified and/or use the appropriate lingua in the line of duty in the world of projects.

This course will expose students to planning, strategizing and executing a project in their field of study or in another field, while engaging the cross section of talent in the class: engineering, computer science, management information systems and business administration students. It will develop students' skills to manage projects and build on leadership skills and ethical reasoning they have acquired in core courses. Student will learn about organizational, environmental, safety and health issues that must be considered during the implementation of a project. Students will also learn, discuss, and reflect on professional issues

such as social responsibility, ethics, licensing, and regulatory reporting. They will be introduced to Industrial Engineering, process management, work measurement, capacity utilization and constraints management.

Hinged on the PMI® Framework for Project Management and using the PMBOK® Guide as the core text, students will network and interact with members of the PMI-Ghana Chapter as they will be recognized as student members for the year. Interested students will also be supported to prep for the CAPM® Certification to enhance their employability after they graduate from Ashesi.

BUSA 424 Venture Capital Investment
Major Elective for BA, MIS. Non-Major Elective for ENG and CS
Prerequisite: TBD
Offered: Typically offered in Fall
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The course expands on the entrepreneurial skills, cash flow appraisal techniques, investing decisions, and financing decisions learned in the prerequisite courses to the structuring of a venture capital (VC) fund, raising VC funds, appraisal of entrepreneurial ventures, allocation of funds to good entrepreneurial ventures, and support for entrepreneurs through the value generation process to the exit point. Students will learn that VC is not just another financing vehicle, but a business building endeavor pursued by the venture capitalist in strict partnership with the entrepreneur to facilitate and accelerate the success of the entrepreneur. The course asks three pertinent questions: What is an attractive sector to allocate VC funds to? Is the entrepreneurial venture a good one? Will allocation of funds to the entrepreneurial venture allow relevant stakeholders to achieve their return goals? The course will provide students with the knowledge and skills needed to answer those questions through lectures, case studies, testimonials from industry, group discussion, and role play.

BUSA 432 Organization Development
Major Elective for BA, MIS. Non-Major Elective for ENG and CS
Prerequisite: FDE 1
Offered: Spring
Course Type: Lecture, Experiential
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1 Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

How can the outcome of capstone applied projects help organizations assess themselves and their environments, leading to the revitalization and rebuilding of their strategies, structures and processes for competitive advantage? What influence tactics can student consultants employ to gain trust from organizations for them to open their doors for them to study their systems for improvement? This course is designed to build the capacities of students who desire to undertake capstone applied projects that contribute towards the effectiveness of organizations.

The course is Organization Development (OD) Consulting in orientation, with a focus on the systematic application and transfer of behavioral science knowledge to the planned development, improvement, and reinforcement of the strategies, structures and processes that lead to organizational effectiveness. It pays attention to the practical resolution of organizations' problems systematically under changing environments, organizational behavior which impacts on its development, techniques or tools that use

authentic data to identify and address organizations' problems and obstacles that inhibit their growth.

BUSA 441 Service Marketing
Major Elective for BA, MIS. Non-Major Elective for ENG and CS
Prerequisite: Quantitative Methods; or Statistics for Engineering & Principles of Economics
Offered: Typically offered in the Fall
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Growing number of school graduates are recruited in service industries. This is because the service sector as a percentage of Gross National Product is substantial and has grown significantly in most countries including Ghana. However, teaching of Marketing in tertiary institutions tends to focus largely on manufacturing or product-based models of business practice which are not always adequate or even in some cases not very useful in making decisions in a service business. The Services Marketing course seeks to teach students the concepts, frameworks and analytical procedures that are best suited to examine and resolve challenges faced by managers and as well as develop successful and coherent marketing strategy/plan for service products.

BUSA 471 Social Enterprise
Major Elective for BA, MIS. Non-Major Elective for ENG and CS
Prerequisite: FDE, Micro-Economics
Other courses that complement this course include Marketing; Corporate Finance; Operations Management; Competitive Strategy; Investments; Economic Development; Branding; New Product Development; Strategic Brand Management; and *Service Marketing.*
Offered: Typically offered in the Spring
Course Type: Lecture, Experiential
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Social Enterprise is an exploratory business elective offered by the business administration department that challenges the student to think in ways that produce sustainable and profitable outcomes that lead to social or environmental impact. Through various team challenges, assessments, and meet the leader sessions students have the opportunity to discuss, examine, and transfer thought into action as they work together to come up with their own solutions for some of their world's toughest challenges.

CS221 Discrete Structures and Theory

Prerequisites: Pre-Calculus 2 or Calculus 1, Introduction to Computing & Information Systems OR Computer Programming for CS OR Computer Programming for Engineering
Ashesi Units: 1; Credit Hours: 4.5; Hours per week classroom: 3; Hours per week discussion: 1.5
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 9 per week)

This course is designed to give students in Computer Science the mathematical foundations they need for their future studies. Specifically, you will learn:

- Mathematical reasoning: how to think logically and mathematically? Understanding and constructing proofs.
- Combinatorial analysis: to be a problem solver, it is important to be able to count objects. We will see some basic techniques for counting.
- Discrete structures: of course, as the name of the course suggests, you will also learn how to manipulate discrete structures (sets, permutations, relations, graphs…).
- Algorithmic thinking: sometimes, we will solve a problem by specifying a list of steps to follow (an algorithm). Algorithms can be implemented through computer programs. By the end of this course, you will know how to describe algorithms (in both English and pseudocode), verify that they work properly, analyze the computer memory and time required to implement them.
- Applications and modeling: applications to show the relevance and practicality of mathematics. We will see applications of discrete mathematics to computer science, data networking and biology. An important problem-solving skill is the construction of mathematical models. We will build our own models while solving some of the exercises.

CS222 Data Structures & Algorithms

Prerequisites: C or better in EITHER Computer Programming for CS OR Computer Programming for Engineering; Concurrent enrolment in Discrete Structures and Theory recommended but not required
Ashesi Units: 1; Credit Hours: 4.5; Hours per week classroom: 3; Hours per week discussion: 1.5
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 9 per week)

This course is about data structures; that is the methods of organizing large amounts of data. It is also about algorithm analysis; that is, the estimation of the running time of algorithms. Specifically, this course will cover fundamental abstract data types and their implementations as data structures, such as lists, hash tables, trees, priority queues, and graphs, as well as asymptotic analyses of algorithms involving these data structures. Students will also learn about recursion, searching (sequential and binary); and sorting (selection sort, insertion sort, merge sort, and heap sort). The Java programming language will be used as the language of implementation in this course, and so Eclipse or IntelliJ will be the recommended development environments.

Course Objectives: At the end of this course, students will be able to:

- Analyze and compute the running time of algorithms, expressing these runtimes using asymptotic notation (Big-O).
- Explain and implement a variety of linear and non-linear data structures.
- Explain and implement fundamental algorithms for searching and sorting.
- Identify and apply appropriate data structures for the solution of practical problems.

CS313 Intermediate Computer Programming
Prerequisites: EITHER Computer Programming for CS OR Computer Programming for Engineering
Ashesi Units: 1; Credit Hours: 4.5; Hours per week classroom: 3; Hours per week discussion: 1.5
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 9 per week)

This course is a continuation of Computer Programming for CS. It will introduce students to more details of object definition and construction and event-driven programming. It will also introduce additional standard Java packages, including the file system and graphical user interface elements. This course will also give students an introduction to C++. Good software engineering practices will be featured in various aspects of the course, and notations like the Unified Modeling Language (UML) will be employed. Through one or more team projects, students will gain experience in designing and implementing larger systems. However, the emphasis of the course will be on the use of prewritten packages and built-in language facilities, as well as design and implementation of moderately sized custom classes and algorithms, rather than on the design of whole systems.

CS 314 Human Computer Interactions
Prerequisites: Introduction to Computing & Information Systems OR Computer Programming for CS OR Computer Programming for Engineering
Ashesi Units: 1; Credit Hours: 4.5; Hours per week classroom: 3; Hours per week discussion: 1.5
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 9 per week)

This course is an introduction to Human Computer Interaction (HCI), a discipline concerned with the design, evaluation, and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them. The course considers the inherently multi- and interdisciplinary nature of HCI and situates various HCI issues in the organizational and societal contexts. It introduces theories of human psychology, principles of computer systems and user interfaces designs, a methodology of developing effective HCI for information systems, and issues involved in using technologies for different purposes.

Learning Objectives: At the end of this course, the student should be able to:

- Explain HCI and interaction design to non-experts.
- Describe cognitive foundations of HCI and user centered design process.
- Gather and understand user requirements.
- Design and evaluate UI of low and medium complexity.
- Communicate effectively about design and evaluation.
- Discuss some of the outstanding research problems in HCI.

CS331 Computer Organization and Architecture
Prerequisites: EITHER Computer Programming for CS OR Computer Programming for Engineering. Completion or concurrent enrollment in Discrete Structures and Theory.
Ashesi Units: 1; Credit Hours: 4.5; Hours per week classroom: 3; Hours per week discussion: 1.5
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 9 per week)

This course presents the fundamental concepts of computer organization and instruction set architectures. Assembly language programming is used to present and illustrate the concepts of instruction set design. The basics of Central Processor Unit (CPU) design and implementation are covered, including some performance enhancing methods like pipelining and memory caches. The interface to the Compiler and Operating System is described in terms of the interaction between the hardware and software

components of a system. The course discusses developments in modern computer system such as parallel processing, virtual computing and other new architectures.

Course Objectives:

- Learn digital system design process.
- Understanding of modern computer architecture.
- Understand Software-Hardware interface.
- Understand low level programming and program execution.

CS341 Web Technologies
Prerequisites: Computer Programming for CS OR Computer Programming for Engineering, Completion or concurrent enrollment in Database Systems
Ashesi Units: 1; Credit Hours: 4.5; Hours per week classroom: 3; Hours per week discussion: 1.5
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 9 per week)

This course introduces the World Wide Web Consortium (W3C) standard markup language and services of the Internet. Topics covered will include basic and advanced HTML, scripting and active pages, design and active pages, design and developing Web-based applications, principles and tools for Web content creation, database fundamentals for the Web, Web management, and Web service delivery. The primary goal of this course is to introduce the relevant technologies and skills needed to design, develop, deploy and manage effective Web Applications. To achieve this goal, we will use a set of 'programming languages': HTML, CSS, JavaScript (AJAX, jQuery, Frameworks or Libraries), PHP, MySQL (relational database management system) and Content Management Systems (CMS).

CS415 Software Engineering
Prerequisites: EITHER Computer Programming for CS OR Computer Programming for Engineering, EITHER Web Technologies OR Intermediate Computer Programming OR Data Structures
Ashesi Units: 1; Credit Hours: 4.5; Hours per week classroom: 3; Hours per week discussion: 1.5
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 9 per week)

This course will introduce a collection of methods which embody an "engineering" approach (i.e., scientific method) to the development of computer software. The content starts with development lifecycle models, such as waterfall, agile development, etc. and then continues to cover requirements specification, the Unified Modelling Language (UML), software architecture, object-oriented analysis and design, design patterns and testing.

Software engineering is an inherently practical subject and applying the concepts being taught is a vital component of developing expertise in this area. Consequently, students undertake a substantial group project, working through a number of stages of the development of a (larger) software application. Students will be supervised but will be expected to largely organize themselves and their work, learning key transferable skills in management and organization.

Learning Objectives

- Appreciate the wider engineering issues that form the background to developing complex and evolving software-intensive systems.
- To understand principles, concepts, methods, and techniques of the software engineering approach to producing quality software.
- To organize and manage a medium-sized software development project, including project plans and documentation, and schedule.

- To make effective technical oral and written presentations.
- Plan and deliver an effective software engineering process, based on knowledge of widely used development lifecycle models.
- Employ group working skills including general organization, planning and time management and inter-group negotiation.
- Capture, document and analyze requirements.
- Translate a requirements specification into an implementable design, following a structured and organized process.
- Make effective use of UML, along with design strategies such as defining a software architecture, separation of concerns and design patterns.
- Formulate a testing strategy for a software system, employing techniques such as unit testing, test driven development and functional testing.
- To think critically about ethical and social issues in software engineering.

CS424 Advanced Database Systems

Prerequisites: Database Systems, EITHER Discrete Structures and Theory OR Data Structures and Algorithms

Ashesi Units: 1; Credit Hours: 4.5; Hours per week classroom: 3; Hours per week discussion: 1.5

Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 9 per week)

Advanced Database Management Systems course deals with the usage as well as concepts of design and architecture of databases. In covering the concepts, theorems and algorithms, proofs relevant to different aspects (design, architecture, and implementation) are covered. The general approach is to go through design, architecture (schema, indexes, and storage), core features (transactions, concurrency), and specialized database usage (data mining & data-warehousing). The practical work done in the course goes through usage of some advanced SQL features and the implementation of some algorithms and coding of internals of an actual database system.

Students should already know structured query language. The course will build further on this to include concepts such as union types and predicates. The diagram format for design may change a bit but it provides students more expressivity for their designs.

Course Objectives:

- To be competent with conceptual and logical database design
- To be able to setup and configure Enterprise DBMS.
- To be able to create and use database objects such as tables, views, stored procedures, functions, indexes, constraints and triggers.
- To be able to design and develop a holistic and efficient database for any system.
- To be able to modify data with logical query processing.
- To be able to troubleshoot and optimize database using tools to analyze query performance.

CS435 Operating Systems

Prerequisites: EITHER Computer Programming for CS OR Computer Programming for Engineering, EITHER Discrete Structures and Theory OR Data Structures and Algorithms

Ashesi Units: 1; Credit Hours: 4.5; Hours per week classroom: 3; Hours per week discussion: 1.5

Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 9 per week)

This is a course on theory and practices of operating system design and implementation. Operating Systems are found in most computing devices we use (e.g., mobile phones, tablets, laptops, televisions, cloud); some are embedded, some are general purpose or specialized –anywhere you find computing, you will find an operating system. All operating systems deal in some way or another with users, security, resources, storage and memory, threads and processes, scheduling, as well as policies associated with or built on these. Our course covers an overview of operating systems, processes, memory, I/O management, file systems and some case studies.

Course Objectives: Upon completion of this course, the students should be able to:

- Explain the concepts, structures, and mechanisms of modern operating systems.
- Design a concurrent system without deadlock.
- Write concurrent programs using multiple threads and processes.
- Describe process execution using various CPU scheduling algorithms.

CS442 E-Commerce
Required for MIS, Elective for CS
Prerequisites: Database Management Systems and Web Technologies
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 4

This is an introduction to e-Commerce principles, technologies, and applications. This course also develops understanding of the problems and requirements of Internet business, and the corresponding solutions. Protocols to ensure secure transactions and e-commerce protocols based on encryption techniques will also be studied. Legal and ethical issues will be discussed, as well as marketing and revenue models for online businesses. Students will get hands on experience building a secure ecommerce site.

Course objectives:

- Students will be able to build an ecommerce application that is secure and uses best practices.
- Students will understand the legal and ethical issues involved in e-commerce.
- Students will understand infrastructure and technology options for setting up an ecommerce site and will have experience deploying some of them.
- Students will be able to determine appropriate revenue models for an online business.

CS452 Machine Learning
Prerequisites: Computer Programming for CS OR Computer Programming for Engineering, Multivariable Calculus & Linear Algebra
Ashesi Units: 1; Credit Hours: 4.5; Hours per week classroom: 3; Hours per week discussion: 1.5
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 9 per week)

This course introduces machine learning. Topics include supervised and unsupervised machine learning, statistical inference and prediction. A wide variety of algorithms will be presented, including logistic regression, K-nearest neighbors, naïve Bayes, decision trees, neural networks, K-means, mixtures of Gaussians, principal components analysis, Expectation Maximization. The course will also discuss modern applications of machine learning such as image segmentation and categorization, speech recognition, and text analysis.

Course Objectives:

- To understand and be able to explain the foundational principles underlying the field of machine learning.

- To be able to implement algorithms for regression, classification, clustering and dimensionality reduction.
- To be able to design suitable machine learning models for a given real-world problem.
- To be able to read and understand machine learning research papers.
- To be able to give presentations on machine learning work to technical and non-technical audiences.

CS 353 Introduction to AI Robotics

Prerequisites: EITHER Computer Programming for CS OR Computer Programming for Engineering; EITHER Calculus II OR Applied Calculus
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week lab: 1.5
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 6-9 per week)

This course gives a practical hands-on as well as theoretical introduction to robotics as a field that integrates expertise in Computer Science, Engineering, Design and Mathematics to create innovative systems that interact with and can operate autonomously or semi-autonomously in the physical world. In this course, students will work individually and in groups to implement robotics projects using robotics platforms such as the Lego EV3 kits, the TurtleBot robot, Interbotix robot arm, among others.

Course Objectives:

1. To understand and be able to explain the foundational principles underlying the field of robotics.
2. To be able to integrate sensors, actuators, and software into a robot designed to undertake some tasks.
3. To be able to implement algorithms for planning and other functionality on robots.
4. To be able to read and understand robotics research papers.
5. To be able to give presentations on robotics work to technical and non-technical audiences.

CS458 Internet of Things

Prerequisites: Computer Programming for CS OR Computer Programming for Engineering
Ashesi Units: 1; Credit Hours: 4.5; Hours per week classroom: 3; Hours per week discussion: 1.5
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 9 per week)

The Internet of Things (IoT) course takes an end-to-end view of IoT including the devices, networks, data analytics, programming, security, and business. It exposes the student to all aspects of a functional IoT system and how to design a secure, robust and scalable IoT network, taking on a hands-on approach. Labs and small projects will be used to gain understanding of key concepts at the various layers. Key among these are the devices, network protocols, data and programming aspects. Students will review hardware types and software tools and be introduced to IoT design principles which cover how to transition from an IoT idea to an IoT product, building of prototypes and commercializing them. Since IoT is still emerging, businesses are going to be either adopting IoT solutions or transforming their existing businesses to include IoT in a seamless and sustainable manner. The course addresses these aspects as well, in order to prepare participants to lead in this budding industry in the business segment.

CS459 Natural Language Processing

Prerequisites: Computer Programming for CS OR Computer Programming for Engineering
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week lab: 1.5
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 6-9 per week)

This an introductory course in Natural Language Processing (NLP). NLP is a subfield of Artificial Intelligence (AI) concerned with computers' ability to process and generate text in everyday human languages. NLP may also deal with textual content in audio and other modalities. This course will seek to give students a basic understanding of what NLP is and introduce them to some state-of-the-art approaches and techniques in NLP while stirring their imaginations to harness the power of NLP for African languages. Since the state-of-the-art for many tasks in NLP uses deep learning, the course will focus on using neural networks for NLP.

Course

- To provide students with a basic understanding of NLP.
- To introduce students to state-of-the-art techniques in NLP
- To stir students' imagination in harnessing NLP for African languages
- To encourage students to think about and apply NLP in solving local and global problems
- To give students a foundation for understanding NLP papers

IS331 IT Infrastructure

Prerequisites: Computer Programming for CS OR Computer Programming for Engineering
Ashesi Units: 1; Credit Hours: 4.5; Hours per week classroom: 3; Hours per week discussion: 1.5
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 9 per week)

This course introduces IT Infrastructure as a shared technology resource for students majoring in Management Information Systems. It covers topics related to both computer and systems architecture and communication networks, with an overall focus on the services and capabilities that IT Infrastructure solutions enable in an organizational context. It gives the students the knowledge and skills that they need for communicating effectively with professionals whose special focus is on hardware and systems software technology and for designing organizational processes and software solutions that require in-depth understanding of the IT Infrastructure capabilities and limitations. The course focuses strongly on Internet-based solutions, computer and network security, business continuity, and the role of Infrastructure in regulatory compliance.

Course Objectives: Upon completion of this course, the students should be able to.

- Understand the principles underlying layered systems architectures and their application to both computers and networks.
- Understand the differences and similarities between the core elements of an IT Infrastructure solution, such as clients, servers, network devices, wired and wireless network links, systems software, and specialized security devices.
- Understand how IT Infrastructure components are organized into Infrastructure solutions in different organizational environments.
- Understand through practical examples how protocols are used to enable communication between computing devices connected to each other.

IS332 System Administration Lab

Prerequisites: Computer Programming for CS OR Computer Programming for Engineering; Prior or concurrent enrolment in IT Infrastructure, Operating Systems or Networks and Data Communications is recommended
Ashesi Units: 1; Credit Hours: 4.5; Hours per week classroom: 3; Hours per week discussion: 1.5
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 9 per week)

This course builds on the theory and practice developed in the IT Infrastructure course, with in-depth experience in configuring and administering IT infrastructure, particularly operating systems, networks, network devices, and security solutions. It provides both conceptual knowledge and practical experience. It also prepares the students for organizational roles that require interaction with external vendors of IT infrastructure components and solutions. Topics of discussions, assignments and lecture time shall include, but not limited to server architectures, authentication and security, network services including firewalls, storage services, performance analysis and tuning, management and configuration of services and system resources, system initialization, cross-platform services, policies and procedures.

Course Objectives: After successful completion of this course, students will be able to:

- Configure an IT infrastructure solution for a small organization, including a network based on standard technology components, servers, security devices, and several different types of computing clients.
- Identify potential sources of poor computer performance and evaluate potential solutions.
- Evaluate alternative policies and mechanisms for providing reliability features of computer system services and operations.
- Apply the core concepts underlying IP networks to solve simple network design problems, including IP planning.
- Configure simple infrastructure security solutions.
- Negotiate with vendors providing design and implementation solutions.
- Cloud Computing.

IS451 Information and Systems Security

Prerequisites: Discrete Structures; Computer Programming for CS OR Computer Programming for Engineering
Ashesi Units: 1; Credit Hours: 4.5; Hours per week classroom: 3; Hours per week discussion: 1.5
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 9 per week)

Information security mechanism is one of the most crucial factors for any organization. Important assets of organization demand a proper risk management and threat model for security hence, information and systems security concepts are gaining a lot of traction. This course will initially cover the concept of information and systems security and software installations process. It will then move on to modules such as threat modelling, risk management and mitigation.

This Course covers the network as well as web scanning. Later in the course it teaches how to use Kali Linux for ethical hacking, it will have different practical sessions on using Kali Linux such as for information gathering, vulnerability analysis, web application analysis, database assessment and password attacks and have some hands-on experience. It will also cover concepts of incident response system, information rights management and so on. It will then guide you towards building your own information security framework best fit for an organization. At the end of this course, you will be well versed with all the factors involved with information security which would help you build a security framework which will be perfect fit for an organizational requirement.

CS361: Introduction to Modelling and Simulation

Prerequisites: EITHER Computer Programming for CS OR Computer Programming for Engineering; EITHER Calculus 1 OR Applied Calculus OR Engineering Calculus; Discrete Structures & Theory
Ashesi Units: 0.5; Credit Hours: 2; Hours per week classroom: 1.5; Hours per week lab: 1.5
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 3-4 per week)

Course Overview:
Real-world systems, such as games, communication networks or transportation systems can be modelled using statistics and a variety of modelling formalisms. This course introduces the process of designing models of existing or proposed real-world systems, and how to use the models to perform simulations that allow for predictions about the future behavior of the system. Programming assignments provide the opportunity to construct prototype modelling tools and simulators based on the theory. In addition, applications from a variety of domains are used to illustrate the different modelling formalism.

Learning Outcomes:

At the end of this course, students will be able to:

1. Be familiar with the introductory concepts that are relevant to modelling, simulation and its application in the industry.
2. Understanding the mathematical foundations, related statistics, and algorithms to be able to comprehend models used in current research.
3. Be able to choose, create, and tune the appropriate models on existing real-life problems. To gain the skills of using the off-the-shelf simulation tools to design simulations for a range of real-world applications.
4. Being a responsible global citizen, following ethical principles, preserving privacy, being aware of potential bias, following FAIR and CARE principles, green computing practices, etc.
5. Creating visualizations as a visual communication to let the simulations speak for better understanding and informed decisions.

Mathematics Track – Mathematics courses taken by various majors at Ashesi are housed in the Computer Science Department.

MATH101 College Algebra
Prerequisites: None
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week lab: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The goal of this course is to help freshmen develop a good knowledge of basic mathematical principles. Because the best way to learn mathematics is to do mathematics, classes will include a lot of meaningful activities through which students will build mathematical intuition, effective problem-solving skills, and discover real-world applications of mathematics.

MATH121 Pre-Calculus 1
Prerequisites: None

Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week lab: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

One definition of mathematics is the science of patterns. Patterns are all around us and the human brain is wired to recognize them. Pre-calculus uses the formal concept of functions to identify and describe patterns found in data, patterns expressed as a formula, and patterns identified visually in a graph. The emphasis of the course is on developing a conceptual understanding of the definition of a function, the characteristics of important function families, connections to real life, and how the study of functions facilitates the understanding of calculus. A focus on problem solving strategies, such as drawing diagrams, systematic lists, looking for patterns, matrix logic, unit analysis, estimation, and others, further develop students' skills in quantitative reasoning.

MATH122 Pre-Calculus 2
Prerequisites: Pre-Calculus 1
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week lab: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

One definition of mathematics is the science of patterns. Patterns are all around us and the human brain is wired to recognize them. Pre-calculus uses the formal concept of function to identify and describe patterns found in data, patterns expressed as a formula, and patterns identified visually in a graph. The emphasis of the course is on developing a conceptual understanding of the definition of a function, the characteristics of important function families, connections to real life, and how the study of functions facilitates the understanding of calculus. A focus on problem solving strategies, such as drawing diagrams, systematic lists, looking for patterns, matrix logic, unit analysis, estimation, and others, further develop students' skills in quantitative reasoning.

Students Learning outcomes:

Mastery of algebra fundamentals.

- Conceptual understanding of functions, including the linear, polynomial, rational, radical, exponential, logarithmic, periodic and related function families, their applications and various forms of representation, such as graphic, symbolic, and tabular forms.
- Ability to apply a problem solving heuristic and appropriate strategies to a wide range of novel and challenging application, logic and quantitative reasoning problems, and present solutions using proper notation and clear communication.

Instructional Objectives

- Content will be presented in a clear and intuitive way using a variety of activities and applications to deepen student understanding and appreciation of functions.

MATH141 Calculus 1
Prerequisites: None
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week lab: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This course seeks to equip students with an intuitive idea of limits. We will discuss continuity and the derivative of a function. Rules of differentiation would be examined and applied. The derivative of the elementary and transcendental functions would be discussed. We would apply the taught theoretical concepts to solve real-life problems.

Course Objectives: The course is expected to expose students to the fundamentals of calculus.

MATH152 Statistics for Engineers
Pre-requisites: Engineering Calculus
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week lab: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This course is a calculus-based, mathematical introduction to the fundamental principles of probability theory, statistics, and applications. Topics include descriptive measures, the axioms and properties of probability, combinatorial analysis used in computing probabilities, conditional probability, independence of events, sampling theory, discrete and continuous random variables, the standard distributions, estimation and hypothesis testing, analysis of variance, regression and correlation, expected value and variance, joint distributions, distributions of a function of a random variable, and sampling distributions. Also included are theoretical results such as Bayes Theorem, Central Limit Theorem, Law of Large Numbers, the Empirical Rule, Hypothesis Testing and Confidence intervals at least for a single mean and a single proportion. Programming in R or a similar language will be used to gain experience with statistical analysis in practice.

MATH 161 Engineering Calculus
Required for CE, EE and ME students
Pre-requisites: none

This course equips students with knowledge of differential and Integral Calculus which is fundamental to the field of Engineering. The focus is three dimensional: Concepts, Methods and Applications. Technology such as graphing utility and GeoGebra will be used to aid concept building and solution process.

MATH211 Multivariable Calculus & Linear Algebra
Prerequisites: TBD
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week lab: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Physical problems require problem solving approaches which combine mathematical thinking and technology to develop modern solutions. Linear algebra and multivariable calculus is a course which provides the essential and foundational toolkit needed to approach such real-life problems. In this course, you will build on your existing differentiation and integration of single variable studied in prerequisite courses and expand into multivariable calculus and linear algebra. Students will learn how to solve variety of equations in multi-dimensional spaces as well as study how to manipulate linear equations and vectors to solve some engineering problems.

MATH221 Statistics with Probability
Prerequisites: Pre-Calculus 2 or Calculus 1
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week lab: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

What influences consumer choices? Why are some people healthier, academically more successful, or more athletic than others? Are you interested in understanding how climate change is impacting communities in your home country? How can the vast amount of data collected and stored online be used to improve our quality of life? The discipline of statistics seeks to turn data into useful information that

can help answer these and many other questions that may pique your interest. In this course, learning statistics will be motivated by using real data to answer questions that YOU are passionate about. Each student will: (1) generate a testable hypothesis from real data; (2) understand how large datasets are structured; (3) format and manage data; (4) conduct descriptive and inferential statistical analysis; and (5) communicate the results of their research to expert and novice audiences. The process of converting data into useful information draws on the following statistical foundation skills taught in the course:

- Producing data
- Exploratory data analysis
- Probability
- Inference

Statistical computing software is the essential tool that ties the quantitative research process together. In this course, you will use R and R Studio to manage data, carry out statistical analysis, conduct simulations, and create graphs and charts to represent data visually – all in the service of answering your own interesting research question!

MATH233 Quantitative Methods
Prerequisites: Pre-Calculus 2 or Calculus 2 AND Statistics or Statistics for Engineering & Economics
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week lab: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This course will survey quantitative approaches to work in the business world. The course introduces students to concepts, techniques and software with which all successful managers should be familiar. The course has three main components: operation research/management science, project management, and statistics.

The course is hands-on, using spreadsheet techniques with minimal reference to complex or abstract mathematics and the R software. The statistical tests will be useful in nearly any senior project work, as well as any significant quantitative decision making in a business context.

Objectives:

1. To develop analytical and conceptual thinking skills.
2. To practice logical approaches to problem-solving.
3. To develop algebraic and spreadsheet modelling skills.
4. To be able to use the R software in solving statistical problems.

Learning outcomes
Upon successful completion of the course, students will be expected to:

1. Apply some commonly used Operational Research/Management Science (OR/MS) techniques.
2. Construct algebraic and spreadsheet models to inform business decisions.
3. Identify data requirements for typical OR/MS methods.
4. Implement models in Excel and interpret solutions from a managerial perspective.
5. Use the R software to solve statistical problems in multiple linear regression, time series analysis, binary logistic regression, etc.

Present a persuasive argument to peers about a business decision based on a mathematical model using appropriate data.

MATH 142 Calculus II
Prerequisites: Calculus I
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1.5

Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 6-9 per week)

Many quantities in Business and the Sciences result from an accumulation or integration process. For instance, total cost of running a coffee shop for a given month, the total revenue accrued by Local Revenue Authorities over a two-year period, the total distance travelled by Inter-City Transport operators, etc. Therefore, accumulation or integration is an everyday experience. In many instances, one can only find information about the rate of change of the desired quantities. Integral calculus is the branch of Mathematics that deals with techniques that lead to complete knowledge of such unknown quantities based on knowledge of their rates of change (derivatives). Key areas of focus of the course include Concepts, Techniques and Application of
Integration to Business and related fields.

Student Outcomes

- Explain key concepts related to Indefinite and Definite integrals.
- Compute Definite and Indefinite Integrals.
- Develop numerical approximations to problems involving Definite Integrals
- Apply the concepts and techniques learnt to real world problems in Business, Economics and the Natural Sciences.

MATH211 Multivariable Calculus & Linear Algebra
Prerequisites: Calculus I & II
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week lab: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

MATH 251 Differential Equations & Numerical Methods
Prerequisites: Multivariable Calculus & Linear Algebra, Applied Programming for Engineering or Computer Programming for CS
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week lab: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This course will introduce students to the topics associated with differential equations and applied numerical methods in solving engineering problems. Students will learn how to translate engineering problems into differential equations, develop MATLAB models and investigate different numerical methods to find solutions.
Using software, students will learn how to solve differential equations, find roots of equations, the method of gradient descent, discrete and continuous optimization, and finding the solution of linear equations using numerical methods. Techniques will be applied in a series of projects focused on engineering applications.

Topics: Analytic differential equations and modeling of engineering problems using differential equations; first order differential equations, systems of two first order equations, second order linear equations; homogeneous linear equations, nonhomogeneous equations; the existence and uniqueness of a solution, approximation; numerical solutions of linear equations, Euler and Runge-Kutta methods; root finding, gradient descent, discrete and continuous optimization; the Laplace Transform and Inverse Laplace Transform.

Engineering Core

Course Title: ENGR 112: Introduction to Engineering

Description: This course will provide a broad overview of the engineering discipline, with the goal of providing a foundation for the rest of the curriculum in terms of engineering concepts, hardware/software skills, and application of the design process. The course will introduce students to basic principles from computer, electrical, and mechanical engineering and challenge them to apply those concepts through the designing and building of a team project. Students will also practice fabrication skills, CAD and Arduino to successfully accomplish their interdisciplinary project. The course is designed to aid students to build an engineering approach to problem-solving. It will also expose the students to potential career trajectories, the ethical standards for professional engineers, and build an eye for using engineering to address local design needs.

This course covers content along three streams. These streams will be covered in parallel through both the lecture and lab sessions. All three are designed to relate to the project for the semester, and their combination will provide students a broad overview of the theories and practices for them to use and build on through the rest of the Ashesi engineering curriculum.

Engineering drawing (CAD), workshop practice, and programming with Arduino are major components of the course.

Pre-requisite: None

Objectives:

1. Gain an overview of the engineering field: disciplines, careers, and aims.
2. Understand the ethical standard to which engineers must be held.
3. Command basic fabrication skills.
4. Understand basic CE, EE, and ME engineering concepts related to the theme for the semester.
5. Apply the engineering design process, in a team.
6. Build simple circuits.
7. Program basic code through Arduino.
8. Generate mechanical designs in SolidWorks.
9. Reflect on their learning journey in engineering.

Topics: Engineering Concepts, Design Process, Hardware/Software Skills:

1. Engineering Concepts: Example topics include energy, circuits, logic & computing, control Systems, Kinematics, and Materials. Additional topics may relate to a particular semester project.
2. Design Process - the engineering design cycle. As each design stage is introduced, the teams will carry them out in relation to the final project.
3. Hardware/Software Skills -The third stream will introduce students to and build their competence in fabrication skills, including soldering, sawing, drilling, joining, etc. It will also cover the use of the SolidWorks CAD software and programming with Arduino.

Practical Sessions:

- CAD using Solidworks including topics such as
    - 2D sketching and dimensioning
    - Extrusions and Extruded cuts
    - Sweeping and lofting
    - fillets and chamfers
    - new planes, mirrored drawings, and patterns
    - fasteners
    - Making parts and assemblies

    - Using a slicer to prepare 3D models for 3D printing
    - Converting models for CNC routing and laser cutting
- Fabrication skills, including soldering, sawing, drilling, joining, welding, 3D printing, Laser cutting, basic woodwork processes, bending processes, etc.
- Introduction to machine shop tools and operations including mill and lathe (both manual and CNC), CNC wood router.
- Programming in C with a microcontroller supported by the Arduino IDE eg ESP8266, ESP32, Arduino variants (Uno, Nano) etc. or similar.
- Basic electronics (with solderless breadboards through to making PCBs).

Mode of delivery: In-person lectures, lab work

Textbooks:

- Fogler, H. S., LeBlanc, S. E., & Rizzo, B. (2013). *Strategies for Creative Problem Solving* (3rd ed.). Prentice Hall.
- Wright, P. H. (2002). *Introduction to engineering* (3rd ed.). John Wiley and Sons, Inc.
- Tickoo, S. (2015). *Solidworks 2015 for Designers* (13th ed.). CADCIM technologies.
- Pfeiffer, W. S., & Adkins, K. E. (2012). *Technical Communication: A Practical Approach: International Edition* (8th ed.). Pearson Higher Education.
- McCarthy, N. (2009). *Engineering: A Beginner's Guide*. OneWorld Publications.
- Giesecke, F. E., & Hill, I. L. (2011). *Technical Drawing with Engineering Graphics* (14th ed.). Peachpit Press.

Course Title: CS 112 Computer Programming for Engineering

Description: This is a first course in computer programming, primarily intended for students pursuing a major in computer science or engineering, and/or who have had some previous programming practice. Topics include computer representation of data, object-oriented programming, variables and assignments, primitive types and operations, conditional execution, iteration, arrays, classes, methods, recursion, object types, encapsulation, inheritance and reasoning about programs. The course includes a laboratory component designed to enhance comprehension.

This course gives students an intensive introduction to programming as a means of problem-solving. It also introduces them to the broader fields of computer science and information systems and shows a connection between computer programming and other disciplines. Concepts will be illustrated in the Python programming language. This course will introduce the object concept, using and declaring functions (methods). Basic software engineering concepts will also be introduced and will be used to solve problems through approximation, simulations, recursive formulas, and data processing.

Prerequisite: *Familiarity with computers*

Objectives:

At the end of the course, students will be able to:

1. Create algorithms for solving simple problems relevant to a variety of domains and application areas.
2. Use the Python programming language to implement, test, and debug algorithms for solving problems.
3. Implement, analyze and explain the behavior of simple programs involving the fundamental programming constructs variables, expressions, assignments, I/O, control constructs, functions, parameter passing, and recursion.
4. Apply object-oriented design and programming to problem-solving.
5. Design software to process data and design simple simulations.

Topics: computer representation of data, object-oriented programming, variables and assignments, primitive types and operations, conditional execution, iteration, arrays, classes, methods, recursion, object types, encapsulation, inheritance and reasoning about programs.

Mode of delivery: In-person lectures, lab work

Textbook: Miller, B. N., Ranum, D. L., & Anderson, J. (n.d.). *Python Programming in Context* (3rd ed.). Jones & Bartlett Learning LLC.

References:

- Allen B. Downey (2016), Think Python 2nd Edition. Available online at https://greenteapress.com/wp/think-python-2e/

Additional References:

- Zelle, John (2003), Python Programming: An Introduction to Computer Science.
- Miller, B. N. & Ranum, D. L. (2019), Python: Programming in Context.

Related online course:

- The Open University, Learn to Code for Data Analysis. Available online at https://www.futurelearn.com/courses/learn-to-code

Course title: ENGR 212 Instrumentation for Engineering*

Description: This course continues the concept of measurement and measurement error that is introduced in the Physics sequence. Students study measurement systems, instruments, and measurement errors, and the use of probability and statistical analysis to design and execute experiments in the presence of measurement errors. An emphasis of the course is the design of instrumentation for experimental problem-solving in real systems.

Prerequisite: Statistics for Engineering and Economics, Physics II: Electromagnetism.

Objectives: The primary focus of instrumentation engineering is the development and implementation of electrical and electronic instruments to measure, monitor, and record physical phenomena. The scope of Instrumentation for Engineering is vast and is fast-growing. The specific objectives are as follows:

1. Explain the basic concepts and definitions in measurement and measurement error.
2. Elaborate discussion about the importance of signal generators and analyzers in measurement.
3. Understand the requirements needed to generate electronic signals for measurement.
4. Understand the basics of electronic measurements that are prerequisites for the study of more sophisticated systems such as automatic measurement and control.
5. Introduce students to monitor, analyze, and control a physical system.
6. Understand how different types of meters, sensors, and transducers work and their construction and useful application.
7. Describe the bridge configurations and their applications.
8. Provide the knowledge and skillset to design and create novel products and solutions for real-life problems.

Topics: Survey of physical quantities typically measured, both physical and electrical. Analog signal conditioning for instrumentation. Measurement errors and implications on experimental design, planning, execution, and analysis. Parameters of sensors and transducers. Applications to process control and instrumentation (including pressure systems, temperature control, flow control, level control). Sensors appropriate to linear or angular acceleration, velocity, and position, DC and AC voltage, electrical resistance, capacitance, or induction. DC null instrumentation, such as Wheatstone Bridges.

Mode of delivery: In-person lectures, lab work

Textbooks:

- Northrop, R. (2014). Introduction to Instrumentation and Measurements (3rd ed.). CRC Press.
- Nilsson, & Riedel. (2015). Electric Circuits (10th ed., Global ed.).
- Hughes, I., & Hase, T. (2010). Measurements and their Uncertainties: A Practical Guide to Modern Error Analysis. Oxford University Press.
- Taylor, J. R. (1996). An Introduction to Error Analysis: The Study of Uncertainties in Physical Measurements (2nd ed.). University Science Books.
- Cha, Rosenberg, & Dym. (2000). Fundamentals of Modeling and Analyzing Engineering Systems. Cambridge University Press.
- Giancoli, D. C. (2008). Physics for Scientists & Engineers Vol. 1. Addison-Wesley.

Course title: ENGR 300 Year 3 Group Project & Seminar*

Description**:** In their third year, engineering students will participate in a one-year group project that ideally cuts across multiple engineering fields (electrical and electronic, mechanical and computer), to revisit the design process at a higher level, to deepen teamwork skills, and to reinforce system level thinking. Part 1 of the third-year project is implemented through *Leadership 4 for Engineers*, which will address leadership, service learning, and responsibilities of the engineering profession to the community. Projects undertaken will include a service-learning component. Students will consider more than technical feasibility in their solutions, but also the desirability and sustainability of their solution to the community and the environment. In the course Third Year Group Project and Seminar, a weekly seminar that will facilitate group meetings and coordinate milestone completions, as well as provide a forum for discussion regarding professional issues and system level design. Students will also be required to reflect on their teamwork experiences, their own learning, and their completed group project, and present their project in a public forum. Learning objectives for the Third Year Group Project and Seminar include a maturing of design thinking and creative thinking skills, consideration of qualities such as environmental and societal impacts of their design, deepening of system-level thinking, project management experience, teamwork and communication skills development.

Objectives:

1. Students will gain an overview of "engineering for community development" and "appropriate technologies" and gain an awareness of the major players in the local ecosystem for this field.
2. Students will know the frameworks available for them to engage in engineering projects, including those for research and design.
3. Students will understand frameworks and tools for assessment of community projects.
4. Students will be able to reflect critically on their learning journey, and they will consider a career that applies their engineering skills to developing communities.
5. Students will be able to clearly document and communicate their work to all relevant stakeholders.

Prerequisite: *Leadership Seminar 3*

Mode of delivery: In-person lectures, discussion sessions

Reference: All foundational text and reference books are reference books for this course.

Course Title: SC 221 Materials Science & Chemistry

Description**:** This course will introduce students to the basic principles of chemistry and their application to materials science and engineering. Students will study the impact of atomic, ionic and molecular structure of materials on their micro-structure and properties, and the relationship between electronic structure, chemical bonding, and atomic order. Principal applications and properties of metals, polymers,

and ceramics, and composites materials will be studied. Examples from industrial practice and emerging technologies will be used, including the environmental impact of chemical processes, the chemistry involved in energy generation and storage (e.g. batteries and fuel cells). At the end of the course, students will be able to identify materials used in engineering and understand their thermo-chemical and electrical properties.

Prerequisite: None (High School Chemistry and Physics)

Objectives:

1. Apply knowledge about material's structure and properties to explain the use of materials for different products.
2. Create and deliver scientific and professional presentations about materials and their properties.
3. Develop and conduct scientifically sound experimental protocols.
4. Analyze the relationship of the materials and its application in a product and presented for a wide audience in an editorial type piece.

Topics: Introductory inorganic and organic chemistry; acid-base equilibria; electrochemistry; biochemistry; chemical kinetics; diffusion; equilibrium phase diagrams; the atomic and molecular structure of materials; the characterization of atomic arrangements in crystalline and amorphous solids: metals, ceramics, semiconductors, and polymers (including proteins); chemical bonding; fundamentals of magnetic behavior, defects and diffusion, equilibrium phase diagrams, and thermal and electrical properties; corrosion; and environmental impact of materials.

Lab exercises: Identification and characterization of materials, Chemical kinetics, mechanical properties of materials, behavior of materials in different environments (e.g., corrosion, chemical modification), heat treatment of materials, Composite design and characterization, SolidWorks Simulation of Materials, Materials Recycling, Polymerization, work hardening (hot and cold working) and the effect of materials and chemicals on the environment.

***Mode of delivery*:** In-person lectures, lab work

Textbooks:

- Askeland, D. R., & Phule, P. R. (2011). *The Science and Engineering of Materials* (6th ed.). Thomson Brooks/Cole.
- Brown, L., & Holme, T. (2014). *Chemistry for Engineering Students* (3rd ed.). Cengage Learning.

Reference:

- Shackelford, J. F. (2014). *Introduction to Materials Science for Engineers: International Edition* (8th ed.). Prentice Hall.
- Callister, W. D., Jr. (2002). *Materials Science and Engineering – An Introduction* (6th ed.). John Wiley and Sons, Inc.
- Hewitt, P. G., Suchocki, J. A., & Hewitt, L. A. (2010). *Conceptual Physical Science Explorations: International Edition*. Pearson Higher Education.

Course title: ENGR 311 System Dynamics

Description: The aim of this course is to exposed students to understand the behavior of engineering systems using systems thinking. The course is an introduction to mathematical modeling of dynamic systems, and response analysis of these systems including, but not limited to, mechanical, electrical, electromechanical, hydraulic, fluid, and thermal systems. The mathematical models will be obtained analytical, but experimental approach will be introduced. Computer simulation of various systems, using appropriate software, will be conducted.

Prerequisite: Engineering Mechanics, Calculus, Linear Algebra, Differential Equations, Circuits & Electronics, Applied Programming for Engineers.

Objective: After successful completion of this course, students will be able to: 1. Apply mathematical modeling of dynamic systems in different engineering fields. 2. Obtain the mathematical models both analytically and experimentally. 3. Solve engineering problems using systems thinking. 4. Develop skills in analyzing, simulating, and identifying dynamic systems based upon their input output responses. 5. Exposed to computer simulation software MATLAB, Simulink, Simscape, and LabVIEW. 6. Understand basic feedback control systems. 7. Exposed to vibration systems.

Topic: Introduction to system dynamics, Laplace transform, transfer function, state-space representation, modeling of mechanical, electrical, electromechanical, fluid, thermal systems, and other systems, time response and analysis of linear systems, computer simulation of dynamic systems, frequency response of linear dynamic systems, introduction of free vibration of single and multi-degree of freedom systems, stability, transient response analysis, linearization of non-linear systems, electric circuit analogs, and introduction to feedback control systems.

Lab Exercises: Modeling, Analysis, and Simulation using MATLAB/Simulink/Simscape and LabView.

Mode of delivery: In-person lectures, Lab work

Textbooks:

- Palm III, W. J. (2013). *System Dynamics* (3rd ed.). McGraw-Hill College.

Reference text:

- Ogata, K. (2013). *System Dynamics* (4th ed., Pearson New International ed.).
- Sayama, H. (2015). *Introduction to the Modeling and Analysis of Complex Systems*. Open SUNY.
- Kluever, C. A. (2015). *Dynamic Systems: Modeling, Simulation, and Control* (1st ed.). Wiley.
- Lobontiu, N. (2010). *System Dynamics for Engineering Students: Concept and Applications*. Academic Press.
- Cochin & Cadwalader. (1997). *Analysis and Design of Dynamic Systems* (3rd ed.). Prentice Hall.
- Vu & Esfandiari. (1996). *Dynamic Systems: Modeling and Analysis*. McGraw-Hill.

Course title: ENGR 312 Control Systems

Description: This course builds on System Dynamics (ENGR311) and introduces students to the theory and practice of control systems. Emphasis is placed on the practical application of the subject to the analysis and design of feedback control systems. Students will model various control systems in the frequency and time domain; mostly, mechanical, electrical, and electrotechnical dynamic systems will be considered. Students will study various classical and modern control techniques that will be used to analyze and design controllers for linear systems. Computer software will be applied in the modeling, analyzing, and designing of the control systems. Simulation results will be compared with experimental results. Practical and industrial examples from different engineering fields will be discussed. The course focus on continuous systems, but digital control systems is introduced. Non-linear dynamic models are also introduced. The course is suitable for students' pursuing computer, electrical, and mechanical engineering, and computer science.

Prerequisite: System Dynamics

Objective: After successful completion of this course, students will be able to:

1. Build on the modeling and analysis techniques from System Dynamics to analyze and design controllers for linear systems and use computer simulations to study them. Practical examples from different engineering fields will be discussed.
2. Analyze system characteristics including stability via root locus and Routh-Hurwitz, sensitivity to parameter variation, disturbance rejection, and steady-state accuracy.

3. Students will analyze and design control systems in both continuous and discrete time, using both classical and modern techniques. Non-linear dynamic models are introduced.
4. Design PI, PD, PID, lead, lag, lag-lead compensators to meet desired system specifications.
5. Design and analyze control system via root locus and Bode plots.
6. Physically realize controllers using electronics hardware.
7. Model the digital computer and implement the digital compensator.

Topic: Topics to be covered include, for continuous systems: classical control – stability analysis (including Routh-Hurwitz criterion), root locus techniques, design via root locus (P, PI, PD, PID, lag, lead, and lag-lead compensators), frequency response techniques (Bode/Nyquist plots), design via frequency response, Bode plot (lag, lead, and lag-lead compensators); modern control – state space, pole placement (controllability), and state estimation/observer (observability); models of physical systems (in the frequency, in the time domain, and reduction of multiple subsystems); time response; steady-state errors; analysis and design of digital control systems (modeling in frequency domain, stability, steady state error, bilinear transformation applications, implementing the digital compensator); nonlinear system analysis; and electro-mechanical actuators and sensors.

Lab exercises: Simulation, design, and implementation of control systems using MATLAB/Simulink/Simscape and LabView. Quanser lab units such as the rotary servo base, ball and beam, linear servo and inverted pendulum, and coupled tanks will be used.

Mode of delivery: In-person lectures, Lab work

Textbooks: Nise, N. S. (2015). *Control Systems Engineering* (7th, Global ed.). Wiley.

Reference text:

- Phillips, C. L., & Parr, J. (2010). *Feedback Control Systems* (5th ed.). Prentice Hall.
- Golnaraghi, F., & Kuo, B. C. (2009). *Automatic Control Systems* (9th ed.). Wiley.
- Ogata, K. (2009). *Modern Control Engineering* (5th ed.). Prentice Hall.
- Franklin, G. F., Powell, J. D., & Emammi-Naeini, A. (2014). *Feedback Control of Dynamic Systems* (7th ed.). Prentice Hall.

Course title: ENGR 401 Senior Project & Seminar

Description: A one hour per week seminar provides a discussion forum for technical writing, ethics and social responsibility, and other topics, and will also serve to guide the project management timeline of the project. At the end of the senior project, students will write a technical report (summary) of their work and do a public presentation of their work. To reinforce professional writing, each member of a senior group project will write-up their own supporting documents.

Prerequisite: Year III group project

Objectives: Learning objectives for the final year capstone project and seminar include a maturation of design and system-level thinking, project management expertise, and a deep understanding of professional issues such as certification, professional boards and oversight, communication, ethics, and responsibility to employers, customers, society, and the environment. Some projects may be very research oriented, and others will lean towards designing, constructing and testing a product or a specific subsystem.

Topics:

- Introduction, context, background and problem statement.
- Literature review and research logistics (library)
- Overview of “Creating an outline of the capstone document”
- Requirements Analysis & Specification

- Design selection process & methodology
- Modeling
- Doing statistical analysis and writing up the full document

Mode of delivery: In-person lectures, discussion sessions

Textbooks:

Reference: All foundational text and reference books are reference books for this course.

Course title: ENGR 413 Project Management and Professional Practice

Description: In this course students will learn to plan, strategize and execute an engineering project. The course will develop students' skills to manage projects and build on leadership skills and ethical reasoning they have acquired in core courses. Student will learn about environmental, safety and health issues that have to be considered during the implementation of a project. Students will also learn, discuss, and reflect on professional issues such as social responsibility, ethics, licensing, and regulatory reporting.

Prerequisite: *Principles of Economics, Leadership Seminar 4 for Engineers, and at least 6 Engineering courses*

Objective: By the end of this session, students should be able to:

1. To analyze a business case and workout the project charter, project scope of a project within an organization. 2. To take up a project manager role in an organization with an ability to plan, execute, monitor and control, close a project successfully.
2. To develop an executive perspective of project management and operations management subject matters in a supply chain organization.
3. To optimize project resources and cost using operations research concepts for decision making.
4. To simulate a project by using a tool to gain insight into long-term profitability of implementing projects for success in an organization.
5. Proficiently use the tools and techniques required for the various knowledge areas to deliver different processes in project management.
6. To adopt and apply professional practices and ethics in project initiation, execution, monitoring and control, and closing of projects (will be exposed to the Engineering Council Act of the Republic of Ghana and the code of ethics of the Ghana Institution of Engineers)

Topics:

Project life cycle, feasibility study, planning, scheduling, cost estimation, resource allocation, budget management, monitoring and evaluation, logistics, management technology, managing project variables (including time management and quality management) professional, ethical, and health and safety issues.
Introduction to Industrial Engineering (theory, practice, application), process management (labour, materials, overhead, risk management), work measurement, capacity utilization and constraints.
The Engineering Council Act of the Republic of Ghana and the code of ethics of the Ghana Institution of Engineers

Mode of delivery: In-person lectures, Lab work

Textbooks:

- Meredith, J. R., & Mantel, S. J. (n.d.). Project Management: A Managerial Approach (9th ed.).
- John Wiley & Sons. Stevenson, W. J., Hojati, M., & Cao, J. (n.d.). Operations Management (6th ed.).
- McGraw-Hill. Taylor III, B. W. (2016).
- Introduction to Management Science (12th ed.).
- Pearson Publishers. PMI. (2017).
- A Guide to the Project Management Body of Knowledge (PMBOK® Guide) (6th ed.). Pennsylvania, USA.

- Hillier, F. S., & Lieberman, G. J. (2015).
- Introduction to Operations Research (10th ed.). McGraw Hill Education.
- van de Poel, I., & Royakkers, L. (2011). Ethics, technology and engineering: An introduction. Wiley-Blackwell.

Additional materials will be recommended and posted on CAMU and CANVAS.

Course Title: SC 113 Physics: Electromagnetism

Description: This course is an introduction to electrostatics, electrodynamics, and electromagnetism. The basic principles behind electrical engineering and electronic communication will be discussed. At the end of the course students will understand simple electronic circuits and the fundamental theories and principles needed to continue their study of electronics and electrical systems. Writing quality lab reports will continue to be emphasized.

Objectives: The objective is to provide students foundational knowledge need to comprehend topics to be covered in subsequent courses. On completion of the course, students will be able to:

1. Compute forces on bodies, in electric fields and in magnetic fields
2. Explain the elemental quantities in electrical engineering including capacitance, inductance, voltage, current, etc. using applicable laws and rules.
3. Analyze AC and DC circuits involving L-C-R components.
4. Explain and analyze the operation of transformers, motors and generators.

Topics: Electric charge, electrostatic fields and potential, Coulomb's law, Gauss Law, electrostatic energy, electric currents, Kirchhoff's Law, alternating voltage and current, rms value, magnetic fields and Ampere's law, time-varying fields and Faraday's law, Maxwell's equations, electromagnetic fields and radiation, energy storage in capacitor and inductor, RLC circuits, conductors, dielectrics, magnetic circuits, principle of transformers, electric motors and generators, electromechanical energy conversion, optics.

Mode of delivery: In-person lectures, lab work

Textbooks:

- Giancoli, D. C. (2008). *Physics for Scientists & Engineers Vol. 2* (4th ed.). Addison-Wesley.
- Pollack, G., & Stump, D. (2002). *Electromagnetism*. Addison-Wesley.
- Hewitt, L. A., Hewitt, P. G., & Suchocki, J. A. (2010). *Conceptual Physical Science Explorations: International Edition* (2nd ed.). Pearson Higher Education.
- Attaway, S. (2013). *Matlab: A Practical Introduction to Programming and Problem Solving* (3rd ed.). Butterworth-Heinemann.
- Hewitt, P. G., Suchocki, J. A., & Hewitt, L. A. (2009). *Practice Book for Conceptual Physical Science Explorations* (2nd ed.). Addison Wesley.

Course Title: CS213: Object-Oriented Programming

Description: This course is a continuation of Computer Programming for CS. The course builds upon the programming concepts from previous course and will develop students' ability to programme using the object-oriented paradigm and the Java language. It will introduce standard Java packages, including the file system and graphical user interface elements. More importantly, the course will teach students to develop more complex applications using the Object-Oriented Programming (OOP) paradigm. It will give students an appreciation of the advantages of OOP; help them define and construct objects; and leverage abstraction, inheritance, polymorphism, and encapsulation to develop robust and maintainable applications.

Objectives: At the end of the course, students will be able to:

1. Develop Java applications including GUI based applications.

2. Leverage OOP to build robust and maintainable applications.
3. Design, develop and document applications for business applications.

Topics:

1. Java Programming Language
2. Defining Classes
3. Inheritance, Polymorphism, Encapsulation and Interfaces
4. Collections Framework
5. File and Network IO
6. GUI Applications

Labs: Lab session consist of individual programs written in lab, as well as a few group projects. Labs cover all topics discussed and progressively integrate knowledge acquired. Two major projects are also included.

Mode of delivery: In-person lecture, lab work

Textbooks:

- Savitch, W. (2017), *Java: An Introduction to Computer Science and Programming,* 8th ed, Prentice-Hall.;
- Savitch, W. (2016), *Absolute Java, 6th Ed.*, Pearson Education Ltd.

References:

- Horstman, C. (2014), Java 8 for the Impatient, Addison Wesley .;
- Schildt, H. (2014), Java 2, The Complete Reference, 9th Ed., Oracle Press .;
- Deitel P., Deitel H., (2014), Java How to Program, 10th Ed., Pearson

Related Online Course:

- Eckel, B., *Thinking in Java.* Available at https://www.mindviewinc.com/ & https://www.bruceeckel.com/
- Oracle Corporation, Sun Java Tutorial- The Swing Trail
- Sun Java online API reference

Course Title: CS331: Computer Organization & Architecture

Description: This course presents the fundamental concepts of computer organization and instruction set architecture. It makes no assumption of a solid background in digital systems design and its building blocks. Consequently, the basic knowledge needed is covered early in the course to make it easy to understand how the components of the computer function. Assembly language programming is used to present and illustrate the concepts of instruction set design. The basics of Central Processor Unit (CPU) design and implementation are covered, including some performance enhancing methods like pipelining and memory caches. The interface to the Compiler and Operating System is described in terms of the interaction between the hardware and software components of a system. The various measures of performance measures of computer systems are also covered. The course discusses developments in modern computer systems such as parallel processing, virtual computing, and other new architectures.

Objectives: After successful completion of this course, students will be able to:

1. Understand modern computer architecture.
2. Learn and apply the basic digital systems design process to design and test an arithmetic and logic unit (ALU).
3. Understand the software-hardware interface of the computer.

4. Understand low level programming and use the knowledge to improve program execution.
5. Develop simple assembly language programs using the MIPS Assembler and Runtime Simulator (MARS). environment to solve applicable real-life problems.
6. Calculate performance and reliability metrics of a given computer system.
7. Evaluate and select the best computer system from a number of given specification options.

Topics:

Topics covered are organized under the following modules:

1. INTRODUCTION
    a. Computer System Layers and Blocks Diagram
    b. CPU: Register File, ALU, Control Unit, Instruction Fetch
    c. Memory, IO, and Bus
    d. Architecture and organization
    e. Computer Abstractions (excludes performance)
    f. Semiconductor technology
2. DIGITAL DESIGN FUNDAMENTALS
    a. Number Systems & Arithmetic for Computers (includes ASCII and UNICODE characters)
    b. Information representation –analog, digital, signals, image, text, sound, video, etc.
    c. Digital Logic Basics
    d. Combinational Logic
    e. Sequential Logic
3. INSTRUCTION SET ARCHITECTURE (ISA)
    a. Detail Discussion on Instruction Set
    b. Endianness
    c. Assembly Language Programming
    d. MIPS instruction set
    e. Type of Instructions
    f. Address Mode
    g. Stack
    h. Procedure
4. THE PROCESSOR
    a. Design of ALU
    b. Control Unit, Finite State Machine, Microprogramming
    c. Instruction Set Design
    d. Pentium/MIPS architecture
    e. Pipelining
    f. RISC/CISC computer architecture
    g. Parallel Processing
5. COMPUTER MEMORY
    a. Types and components of memory
    b. Memory organization
    c. Memory Hierarchy
    d. Virtual memory
    e. Hardware examples
6. PERFORMANCE & RELIABILITY
    a. Performance metrics
    b. Benchmarking
    c. Performance evaluation
    d. Computer Systems Reliability

7. ADVANCED ARCHITECTURES
    a. Introduction to parallel processors and computing
    b. Introduction to GPU programming
    c. Hyper-threading
    d. Virtualization
    e. Cloud computing

Textbooks:

- John L. Hennessy (2013), *Computer Organization and Design MIPS Edition: The Hardware/Software Interface 5th edition*.
- Sivarama P. Dandamudi (2013), *Fundamentals of Computer Organization and Design.*

References:

- Thomas L. Floyd (2015), *Digital Fundamentals 11th Global Edition*.
- William Stallings (2015), *Computer Organization and Architecture 10th Global Edition*.
- S. Brown and Z. Vranesic (2008), *Fundamentals of Digital Logic with VHDL Design*
- Randal E. Bryant and D. O'Hallaron (2015), *Computer System: A Programmer's Perspective*.

Course Title: CE 122 Applied Programming for Engineers*

Description: In this course, you will be introduced to basic computer programming techniques and build on your existing computer programming experience and learn how to use programming to solve real-life engineering and scientific problems. You will improve on the modeling skills you have gained from the mathematics and physics courses you took and apply them to develop engineering simulations. You will gain experience in writing computer programs in the MATLAB and C programming languages. You learn how to write about your project in a scientific report. We will also discuss/introduce different ways of applying some programming techniques in courses like Big Data Analysis, Differential Equations, Numerical Methods, Control Systems and System Dynamics.

Prerequisite: Computer Programming for Engineers

Objectives:

1. Ability to model mathematical and engineering problems using MATLAB.
2. Ability to understand programming language syntax and its definition.
3. Ability to write simple programs in Matlab and C language by using basic control structures (conditional statements, loops, switches, branching, etc.).
4. Ability to create a programmable model for a problem given.
5. Understand a function concept and how to deal with function arguments and parameters.
6. Basic knowledge of working with arrays in Matlab and C language.
7. Understand a programming concept and have the ability to handle possible errors during program execution.
8. Ability to apply programming concepts in C and Matlab language to solve engineering and scientific problems.

Topics: Programming in MATLAB: elementary matrix and vector operations, looping and vectorization, logical conditions and operators, cell array operations, code debugging; Scientific writing, how to write a script and a user-defined function file, plotting in 2D & 3D, fitting data to a model, creating animations and movies. Introduction To Programming in C: Fundamentals of C program, Selection, and looping statements, dealing with arrays, pointers, and maximizing your computer's memory.

Lab Exercises: Scientific programming and simulations. Modeling specific problems: Models of forces and falling motion, pendulum motion, gas motion and disease spread. etc.

Mode of delivery: In-person lectures, lab work

Textbooks:

- Attaway, S. (n.d.). MATLAB: A Practical Introduction to Programming and Problem Solving (3rd or 4th ed.).
- Greg Perry, Dean Miller. (2013) "C Programming Absolute Beginner's Guide", 3rd ed., Que Publishing, 2013.

References:

- Paul Deitel and Harvey Deitel (2013). "C for Programmers with an Introduction to C11", Prentice Hall.
- Shiflet, A., & Shiflet, G. (2014). Introduction to Computational Science: Modeling and Simulation for the Sciences (2nd ed.). Princeton University Press.
- Hubbard, J., & Sprankle, M. (2009). Problem Solving and Programming Concepts (8th ed.). Pearson Prentice Hall.
- Deitel, P. (2012). C: How to Program (7th ed.). Prentice Hall.
- Zelle, J. (2010). Python Programming: An Introduction to Computer Science (2nd ed.). Franklin, Beedle & Associates.
- Lutz, M. (2013). Learning Python (5th ed.). O'Reilly.

Course Title: EE 222 Circuits and Electronics

Description: In this course students will study the principles and workings of electronic components and design circuits common in electronic systems like amplifiers and filters. Students will learn how to develop mathematical models for electronic circuits and analyze circuit responses in the time and frequency domain. At the end of the course students should have learnt how to model and design simple analog electronics systems. Students will learn to analyze electrical circuits in single- and three-phase power systems.

Prerequisite: Physics: Electromagnetism

Objectives: After successful completion of this course, students will be able to;

1. Model and analyze circuits with passive components using common circuit analysis techniques. (eg application of Kirchhoff and node voltage analysis for both dc and ac circuits)
2. Configure op amps in a variety of configurations,
3. Understand, analyze and design circuits involving diodes, BJTs and MOSFETS (eg an amplifier)
4. Analyze circuits in the time and frequency domain at steady state. (eg frequency response of a filter
5. Calculate active and reactive power for single and 3 phase circuits
6. Will have acquired the skill to use SPICE tools for simulation and
7. Will be able to design and build simple analog electronic circuits with discrete components and op amps. (eg oscillator)

Topics: Electronic components (resistors, capacitors, inductors, diodes, transistors, relays, switches and transformers), solid state components (diodes, transistors, Zener, photo diode, FET, MOSFET), circuit analysis, Kirchhoff's Laws, Norton's Theorem, Thevenin's Theorem, electronics networks, analog electronic circuits like amplifiers and filters, power sources, time domain and frequency domain solutions, op-amp circuits, analysis of ac circuits, phasors, active and reactive power calculations, balanced 3 phase circuits,

Labs: Characteristics of electronic components like diode, pn junction, transistor, analysis and simulation of analog circuits with SPICE software, design of amplifiers, filters, rectifiers, oscillators, etc.

Mode of delivery: In-person lectures, lab work

Textbooks:

- Nilsson, J. W., & Riedel, S. (2014). Electric Circuits: Global Edition (10th ed.). Pearson Higher Education.
- Sedra, A. S., & Smith, K. C. (2009). Microelectronic Circuits (6th ed.). Oxford University Press.

Reference:

- Hambley, A. (2014). Electrical Engineering Principles and Applications (6th ed.). Pearson.
- Franco, S. (2014). Design with Operational Amplifiers and Analog Integrated Circuits (4th ed.). McGraw-Hill.
- Rabaey, J. M., & Chandrakasan, A. (2003). Digital Integrated Circuits (2nd ed.). Prentice Hall.
- Dorf, R. C., & Svoboda, J. A. (2010). Introduction to Electric Circuits (8th ed.). Wiley.

Course Title: CE 122 Applied Programming for Engineers*

Description: In this course, you will be introduced to basic computer programming techniques and build on your existing computer programming experience and learn how to use programming to solve real-life engineering and scientific problems. You will improve on the modeling skills you have gained from the mathematics and physics courses you took and apply them to develop engineering simulations. You will gain experience in writing computer programs in the MATLAB and C programming languages. You learn how to write about your project in a scientific report. We will also discuss/introduce different ways of applying some programming techniques in courses like Big Data Analysis, Differential Equations, Numerical Methods, Control Systems and System Dynamics.

Prerequisite: Computer Programming for Engineers

Objectives:

1. Ability to model mathematical and engineering problems using MATLAB.
2. Ability to understand programming language syntax and its definition.
3. Ability to write simple programs in Matlab and C language by using basic control structures (conditional statements, loops, switches, branching, etc.).
4. Ability to create a programmable model for a problem given.
5. Understand a function concept and how to deal with function arguments and parameters.
6. Basic knowledge of working with arrays in Matlab and C language.
7. Understand a programming concept and have the ability to handle possible errors during program execution.
8. Ability to apply programming concepts in C and Matlab language to solve engineering and scientific problems.

Topics: Programming in MATLAB: elementary matrix and vector operations, looping and vectorization, logical conditions and operators, cell array operations, code debugging; Scientific writing, how to write a script and a user-defined function file, plotting in 2D & 3D, fitting data to a model, creating animations and movies. Introduction To Programming in C: Fundamentals of C program, Selection, and looping statements, dealing with arrays, pointers, and maximizing your computer's memory.

Lab Exercises: Scientific programming and simulations. Modeling specific problems: Models of forces and falling motion, pendulum motion, gas motion and disease spread. etc.

Mode of delivery: In-person lectures, lab work

Textbooks:

- Attaway, S. (n.d.). MATLAB: A Practical Introduction to Programming and Problem Solving (3rd or 4th ed.).
- Greg Perry, Dean Miller. (2013) "C Programming Absolute Beginner's Guide", 3rd ed., Que Publishing, 2013.

References:

- Paul Deitel and Harvey Deitel (2013). “C for Programmers with an Introduction to C11”, Prentice Hall.
- Shiflet, A., & Shiflet, G. (2014). Introduction to Computational Science: Modeling and Simulation for the Sciences (2nd ed.). Princeton University Press.
- Hubbard, J., & Sprankle, M. (2009). Problem Solving and Programming Concepts (8th ed.). Pearson Prentice Hall.
- Deitel, P. (2012). C: How to Program (7th ed.). Prentice Hall.
- Zelle, J. (2010). Python Programming: An Introduction to Computer Science (2nd ed.). Franklin, Beedle & Associates.
- Lutz, M. (2013). Learning Python (5th ed.). O’Reilly.

Course Title: CE 322 Digital Systems Design

Description: In this course students will study the principles of digital systems and computers. They will learn digital system theory and design techniques, including Boolean algebra, binary arithmetic, digital representation of data, truth tables, gates, flip-flops, finite state machines, memory, and timing issues. Students will gain experience with several levels of digital systems, from simple logic circuits to microcontrollers, in order to design, simulate and implement digital systems. They will also learn how processors and microcontrollers are used for control by interfacing sensors and actuators.

Prerequisite: *Circuits and Electronics*

Objectives: After successful completion of this course, students will be able to

1. Design combinational and sequential logic circuits (including using standard logic ICs)
2. Implement digital designs using VHDL
3. Deploy digital designs using FPGA hardware. (for virtual labs – simulation of VHDL code)
4. Interface digital systems to analog systems

Topics: Binary numbers and operations, Boolean algebra, combinational and sequential logic, digital system design, finite state machines, hardware description language (such Verilog or VHDL), programmable devices, ADC and DAC, interface protocols, processor and microcontroller architecture and interface.

Mode of delivery: In-person lectures, discussion sessions

Textbooks: Floyd, T. L. (2008). *Digital Fundamentals* (10th ed.). Prentice Hall.

Reference:

- Brown, S., & Vranesic, Z. (2009). Fundamentals of Digital Logic with VHDL Design (3rd ed.). McGraw-Hill.
- Dally, W. J., & Harting, R. C. (2012). Digital Design: A Systems Approach. Cambridge University Press.
- Katz, R. H., & Berriello, G. (2004). Contemporary Logic Design (2nd ed.). Prentice Hall.
- Dandamudi, S. (2003). Fundamentals of Computer Organization and Design. Springer.

Course Title: CE 451 Embedded Systems

Description: This course will cover the design and implementation of embedded systems from a hardware and software perspective. Students will go through the design process of embedded systems and analyze the tradeoff between a hardware and software implementation. They will also learn software development techniques unique to embedded systems such as real-time operations, I/O operations, and communications. The bare metal approach to embedded systems development is highlighted. Students will learn to read data sheets and implement drivers with bit-level manipulation. There is an emphasis on creating responsive multitasking systems. An introduction to a Real Time Operating System will be given.

Prerequisite: Digital Systems Design

Objective: After successful completion of this course, students will be able to

1. Design an embedded system given user requirements.
2. Evaluate what microcontroller to choose to address a problem, given a set of constraints.
3. Create embedded systems software that employs cooperative multitasking and interrupts to make a responsive system.
4. Make use of common microcontroller peripherals including GPIO, timers & counters, analog I/O, and serial communications to interface the real world.
5. Use ARM Assembly Language (based on ARM Cortex-M0+).
6. Properly organize/structure embedded C code (use of finite state machines, to improve responsiveness and organization of code into files and libraries).
7. Use Assembly and C together to improve efficiency of embedded systems software.
8. Interpret datasheets for electronic components and microcontrollers to be able to create appropriate reusable C based libraries.
9. Analyze embedded system requirements and the tradeoff between hardware and software implementation.
10. Integrate embedded subsystems in higher voltage systems.

Topics: Introduction to Embedded System Design; Embedded Programming in C/C++; Integrating C and Assembly Language; Cortex-M0+ CPU Core and registers; Software design for embedded systems and concurrency; Interrupts; General Purpose Input-Output (GPIO); Analog Interfacing; Timers; Serial Communications; Direct Memory Access

Mode of delivery: In-person lectures, discussion sessions

Textbooks:

- Dean, A. G. (2017). Embedded Systems Fundamentals with ARM Cortex-M based Microcontrollers: A Practical Approach.
- Amanquah, N. (2020). Embedded Systems notes.

Reference:

- Yiu, J. (2015). The Definitive Guide to ARM Cortex -M0 and Cortex-M0+ Processors (2nd ed.). Newnes.
- Floyd, T. L. (2008). Digital Fundamentals (10th ed.). Prentice Hall.
- Sass, R., & Schmidt, A. G. (2010). Embedded Systems Design with Platform FPGAs: Principles and Practice. Morgan Kaufmann.

Electrical Engineering Courses

Course title: EE 242 Introduction to Electrical Machines

Description: This course introduces students to the fundamental principles underlying electro-mechanical machines and devices, their design, and their maintenance. It provides a treatment of transformers, synchronous generators and motors, induction motors, speed and torque control, protective devices, and introduction to DC Machines.

Prerequisite: *Physics II: Electromagnetism and Multivariable Calculus & Linear Algebra.*

Objectives: After successful completion of this course, Students will be able to:

1. Apply magnetic circuit concepts to determine magnetic fields in practical devices.
2. Use equivalent circuit of real transformers to determine their regulations and power Efficiencies.
3. Select the proper ac motor or generator type for various applications.

4. Use equivalent circuits to determine developed torque, speed, and other characteristics (mechanical or electrical quantities) of rotating machinery.
5. Control motor speed (depending on motor type), set up starting/run configurations for motors and generators.
6. State how torque varies with speed for various machines.

Mode of delivery: In-person lectures, Lab work

Topics: Introduction to machinery principles; Transformers; Synchronous Generators; Synchronous Motors; Induction Motors; DC Machinery Fundamentals etc.

Textbook: Chapman, S., (2011) Electric Machinery Fundamentals, 5th Ed., McGraw-Hill.

Reference:

- Kingsley Jr., C., Umans, S., Fitzgerald, A., (2013) Electric Machinery, 7th Ed, McGraw-Hill.
- Oberg, E., (2012) Machinery's Handbook, 29th Ed., Industrial Press.
- Schavemaker, P., (2008) Electrical Power System Essentials, Wiley.
- Lindeburg, M. R., (2013) Mechanical Engineering Reference Manual, Professional Publications

Course title: EE 342 Advanced Electrical Machines

Description: This is an advanced class that provides students further principles governing the operation of electro-mechanical machines and devices, their design, and their maintenance. There is also a treatment of special purpose motors such as variable reluctance machines and stepping motors. It provides an advanced treatment of power electronics and motor drives, DC motors and DC generators.

Prerequisite: Introduction to Electrical Machines and Power Electronics

Objectives: After successful completion of this course, Students will be able to:

1. Understand how voltage is induced in a rotating loop.
2. Understand commutation in dc machines.
3. Know the types of dc motors in general use.
4. Be able to perform nonlinear analysis of dc motors and generators using the magnetization curve, considering armature reaction effects.
5. Understand how to control the speed of different types of dc motors and generators.
6. Understand the special characteristics of dc motors and generators, and the applications that they are especially suited for.
7. Understand how it is possible to develop unidirectional torque from a pulsating magnetic field in a single-phase induction motor.
8. Understand the basis of operation of ac motor drives.
9. Identify and design motor drive circuits for motor speed control.

Mode of delivery: In-person lectures, Lab work

Topics: DC Machinery Fundamentals; DC Motors; DC Generators; Single Phase and Special Purpose Motors; Power Electronics and Motor Drives.

Textbook: Chapman, S., (2011) Electric Machinery Fundamentals, 5th Ed., McGraw-Hill.

Reference:

- Kingsley Jr., C., Umans, S., & Fitzgerald, A. (2013). Electric Machinery (7th ed.).
- McGraw-Hill. Oberg, E. (2012). Machinery's Handbook (29th ed.).
- Industrial Press. Schavemaker, P. (2008).Electrical Power System Essentials.
- Wiley. Lindeburg, M. R. (2013). Mechanical Engineering Reference Manual. Professional Publications

EE 421 Digital and Analog Signal Processing in Telecommunications
Elective for CE and EE students
Prerequisite: Communication Systems
Credit Hours: 4; Ashesi Credit Units: 1; Hours per week classroom: 3; Hours per week discussion/lab: 3

This course includes the study of signal processing and technology used in the telecommunication industry. Students will study various digital and analog signal processing techniques. Starting from the basic definitions of a discrete-time signal, through Fourier analysis, filter design, sampling, interpolation and quantization, more advanced tools are studied to aid the study and design of digital communications systems. Note: CE and EE students wishing to work in the telecommunications industry are advised to take *Digital and Analog Signal Processing in Telecommunications* as one of their electives.

Topics: Discrete time signals and systems; transform analysis of linear time invariant systems, z-transforms, sampling of continuous-time signals, structures for discrete-time systems, Fourier transforms, fast Fourier transforms, computation of the discrete Fourier transform, Fourier analysis of signals using the discrete Fourier transform, signal averaging, signal compression, convolution, parametric signal modeling, discrete Hilbert transforms filters, complex techniques, and applications of all of these.

Lab Exercise: Signal processing, spectrum analysis.

Textbook: Oppenheim, A. V., & Schafer, R. W. (2010). Discrete-Time Signal Processing (3rd ed.). Pearson..

***References*:**

- Lyons, R. G. (2010). Understanding Digital Signal Processing (3rd ed.). Prentice Hall.
- Smith, S. (2002). Digital Signal Processing: A Practical Guide for Engineers and Scientists (3rd ed.). Newnes.
- Prandoni, P., & Vetterli, M. (2008). Signal Processing for Communications. EPFL Press.
- Ifeachor, E.C., & Jervis, B.W. (2001). Digital Signal Processing: A Practical Approach (2nd ed.). Prentice Hall.

Course Title: ME 301 Mechanical Machine Design

Description: This course covers the principles and current practices of machine element design, including solid modeling and finite element analysis (FEA). The course introduces the design of machine members for static and fatigue strength. The design and selection of common machine elements such as shafts, gears, bearings, springs, keys, power screws and fasteners will be considered. As part of the course there will be a group design project that will involve the use of engineering (mechanical) design process, CAD, FEA, CAM, fabrication of machine components and assemblies to design a physical system and build a working prototype to satisfy design requirements for a given need. Other topics such as codes and standards, project planning and communication skills are also covered.

Prerequisite: *Mechanics of Materials*

Objectives: After successful completion of this course, students will be able to;

1. Perform load analysis of different components in a mechanical system.
2. Design a mechanical component (including standard ones), analyze the designed component to prevent failure (static and fatigue) and to satisfy a set of design constraints.
3. Analyze and design axles and transmission shafts using the ASME code.
4. Model a mechanical system with CAD software.
5. Conduct stress, deflection, vibration, and impact analyses of mechanical elements and assemblies using finite element method (FEA) software.
6. Conduct some machining processes manually and computer controlled.
7. Conduct design optimization using a FEA software.

8. Understand and apply the engineering design process.
9. Apply engineering principles to design a physical system and build a working prototype to satisfy design requirements for a given design need.
10. Function in a team environment: (i) contribute to the team project, (ii) take responsibility in the team, and (iii) recognize and value other team members' skills.
11. Give technical presentation.
12. Understand codes, standards, professional and be ethically responsible

Mode of delivery: In-person lectures, Lab work

***Topics*:** Principles of Machine Design, Load and Stress Analysis for Design, Deflection of Machine Members, Analysis and Design of Machine Members under Static Loading, Analysis and Design of Machine Members under Fatigue Loading, Design of Transmission Shafts and Axles, Engineering Design Process, Ethics, and Standards, Keys and Seals, Bearings (Rolling Contact Bearings), Gears and Gearing (Spur, Helical, Bevel and Worm), Springs, Lubrication, Belt Drives and Chain Drives, and Bolted Joints.

Textbook: Richard G. B., & Keith, J. N. (2015). *Mechanical Engineering Design* (10th ed.). Shigley's.

***Reference*:**

- Robert, M. (2013). Machine Elements in Mechanical Design (5th ed.). Prentice Hall.
- Jack, C., Henry, B., & George, S. (2009). Mechanical Design of Machine Elements and Machines, (2nd ed.). Wiley.
- Theodore, W. (2006). Electrical Machines, Drives and Power Systems (6th ed.). Pearson Higher Education.
- Erik, O. (2012). Machinery's Handbook (29th ed.)., Industrial Press.
- Michael, R. L. (2013). Mechanical Engineering Reference Manual, Professional Publications.

Course title: ME 311: Mechanics of Materials

Description: This course introduces the theory and application of static engineering mechanics as it relates to statically determinant and indeterminant structural systems. The course involves determination of stresses, deformations, and strains. The course will cover internal resultant loadings in simple plane trusses and beams, elastic properties of solids under axial and torsional loads, stress, strain, and deformation due to axial, torsional, bending, thermal, transverse loads, combined loading, deflection of beams, and columns. Also, transformation of stress and stresses in thin-walled pressure vessels will be covered. The course includes the use of computational software to solve practical engineering problems numerically.

Prerequisite: *Engineering Mechanics, Materials Science & Chemistry*

Topics: Introduction (Equilibrium Condition, Concept of Stress, Strain, Deformation, Elasticity, etc.), Axial Loading, Torsion, Pure Bending, Analysis and Design of Beams for Bending, Shearing Stresses in Beams and Thin-Walled Members, Transformations of Stress and Strain, Principal Stresses under a given Loading, Deflection of Beams, and Columns.

Mode of delivery: In-person lectures, Lab work

Textbook:

- Beer, F. P., Johnston, E. R., Jr., DeWolf, J.T. & Mazurek, D.F. (2017). Mechanics of Materials, (7th ed.). McGraw Hill, Inc.

***Reference*:**

- Huei-Huang, L. (2015). Mechanics of Materials Labs with SolidoWorks Simulation. SDC.Mission.
- Frank, D., Hassan, Al N., Morgan, W., & Williams, D. (2010). Structural Mechanics: Loads, Analysis, Design and Materials,(7th ed.). Trans-Atlantic Publications.
- Roy, R. C. Jr., (2011). Mechanics of Materials, (3rd ed.). Wiley.

- James, M. G. & Barry J. G. (2012). Mechanics of Materials, (8th ed.). Cengage Learning.
- Nash, W. (2019). Schaum's Outline of Strength of Materials, (7th ed.). McGraw-Hill.
- Russell, C. H. (2013). Mechanics of Materials, (9th ed.). Prentice Hall.

Course title: ME212: Thermodynamics

Description: This course is an applied foundation course in thermal science designed to introduce students to the fundamental concepts and the laws of thermodynamics. It extends to the applications of the first and second laws of thermodynamics to systems devised for the production of mechanical power, cooling and heating. The course teaches students about the principles, operations, design, and analysis of thermal systems including power generation, refrigeration, Air conditioning and combustion of fuels. Students will also be introduced to non- conventional power generation resources and utilization.

Prerequisite: Engineering *Mechanics and Calculus.*

Objectives: After successful completion of this course, students will be able to:

1. Understand concepts and definitions of thermodynamics.
2. Identify properties of a pure substance.
3. Understand about work and heat.
4. Describe about the first law of thermodynamics.
5. Understand about first law analysis for a control volume.
6. Understand material removal processes.
7. Describe the second law of thermodynamics.
8. Understand about second law analysis for a control volume.
9. Understand about power and refrigeration cycles.

Mode of delivery: In-person lectures, Lab work

Topics: Basic concepts of thermodynamics, energy, energy transfer and general analysis, Thermodynamics laws (first and second), thermodynamic properties of pure substances and states, energy and mass analyses of closed and open systems, reversible and irreversible processes, entropy, thermodynamic equilibrium, mass and energy conservation, power and refrigeration cycles – Carnot, Rankine, Brayton, and Otto cycles.

Software Required: Phet Sims, Vernier Logger Pro, SciLab, Originpro,

Textbooks:

- Cengel, Y. A., Cimbala, J. M., & Turner, R. H. (2012). Fundamentals of Thermal-Fluid Science (4th ed.).
- McGraw-Hill. Cengel, Y. A., Cimbala, J. M., & Turner, R. H. (2017). Fundamentals of Thermal-Fluid Science (5th ed.).
- McGraw-Hill. Çengel, Y. A., & Boles, M. A. (2015). Thermodynamics: An Engineering Approach (8th ed.). McGraw-Hill.

Reference:

- Moran, M. J., Shapiro, H. N., Munson, B. R., & DeWitt, D. P. (2003). Introduction to Thermal Systems Engineering: Thermodynamics, Fluid Mechanics, and Heat Transfer. Wiley.
- Rogers, G.F.C., & Mayhew, Y. (1996). Engineering Thermodynamics: Work and Heat Transfer (4th ed.). Longman.
- Eastop, T.D., & McConkey, A. (1993). Applied Thermodynamics for Engineering Technologists (5th ed.). Prentice Hall.

Course Title: ME422 Heat Transfer

Description: The course builds understanding of the physical behavior of various modes of heat transfer, including conduction, convection, and radiation. It also includes the design and sizing of heat exchangers; fundamentals of air conditioning and refrigeration vapor cycles, and an introduction to numerical modeling and analysis using finite element analysis software (e.g., SolidWorks Simulation). Labs and projects will involve temperature measurements and the design-build-analysis-test of thermal systems..

Prerequisite: Thermodynamics and Fluid Mechanics

Objectives: This course aims to:

1. By inspection, determine which modes of heat transfer are occurring.
2. Calculate transient and steady heat flux and temperature distributions for one-dimensional heat conduction.
3. Characterize heat transfer from external and internal fluid flow using dimensionless numbers.
4. Evaluate surfaces (e.g., configuration, reflectivity, color) in terms of radiative heat transfer.
5. Use basic models to analyze and evaluate the performance of heat exchangers.
6. Set up and carry out a thermal analysis using commercial finite element software.
7. Measure temperatures using Arduino and related hardware.

Topics: Relationship of heat transfer to thermodynamics, heat transfer modes, conduction topics: in 1D steady-state and transient analysis for cartesian and cylindrical coordinate systems, extended surfaces, energy generation, transient response of lumped models, thermal circuit representations, first-order systems, fundamentals of convection, dimensional analysis of convection heat transfer coefficient , external flow analysis of heat transfer , internal flow analysis of heat transfer, boundary layers, laminar vs. turbulent flow, natural convection, forced convection, radiation heat transfer analysis, heat exchanger design and analysis, FEA of thermal analysis and thermal stress analysis. .

Mode of delivery: In-person lectures, Lab work

Textbooks:

- Cengel and Ghajar, Heat and Mass Transfer: Fundamentals and Applications. McGraw-Hill Education. Any edition.
- Frank P. Incropera and David P. DeWitt Introduction to Heat Transfer, John Wiley and sons Inc., any edition
- T. L. Bergman, A. S. Lavine, Introduction to Heat Transfer, 8th, John Wiley and Sons Inc.

***Reference*:**

- J. P. Holman, (2009) “Heat Transfer,” 10th Edition, McGraw-Hill, Inc., New York
- Lienhard J. & Lienhard J. (2020). A Heat Transfer Textbook (5th ed). Phlogiston Press. PDF available for download at https://ahtt.mit.edu/ Note: Solutions manual is also available for download (use for practice).

Course title: ME 431 – Fluid Mechanics

Description: How can we model and analyze problems involving fluids? This course investigates the application of fluid mechanics in engineering and industrial processes. We will discuss theories and principles of fluid dynamics and statics using engineering applications as examples. Students will learn various analytical approaches to model and solve basic fluid problems. They will experimentally solve problems during the labs, and they will learn to design to a first-order, fluid systems like pipes and pump systems. At the end of the course students should be able to design and analyze different fluid systems.

Prerequisite: Thermodynamics

Objectives: After successful completion of this course, students will be able to

1. Gain appreciation of and intuition for fundamental fluid-mechanical phenomena

2. Understand the dynamics of a range of fluid flows in terms of the governing non-dimensional parameters and equations
3. State the conservation principles of mass, linear momentum, and energy for fluid flow
4. Create models of inviscid, steady fluid flow over simple shapes
5. Determine basic forces and moments acting on simple profiles in inviscid, steady flow
6. Describe boundary layer behavior and derive its value from a given velocity profile
7. Construct potential flow models of basic flows
8. Apply common laboratory techniques to investigate fluid flows
9. Conduct basic sizing for pumps and other industrial fluid machinery

Topics**:** This course begins by laying the analytical groundwork for fundamental fluid analysis: fluid properties, kinematics of a fluid element, control volume analysis, and differential governing equations. Dimensional analysis is covered to enable generalization of findings in fluids problems. Internal flows are then treated, including pipe flow and a brief description of turbulence modeling. External flows come next, covering boundary layer theory, drag, lift, and wakes. Potential flow is introduced, at which point airfoil theory also comes in. Turbomachinery, such as pumps, wind turbines, etc. are introduced both in theory and in lab. Open channel and compressible flows will be covered as time permits.

Mode of delivery: In-person lectures, Lab work

Textbook**:**

Frank, M. W. (2015) *Fluid Mechanics* (8th ed.). McGraw Hill.

Reference text:

- Alexander, S. A Physical Introduction to Fluid Mechanics, (2nd ed.)., http://efluids.com/efluids/books/efluids_books.htm
- Fluid Dynamics and Heat Transfer: An introduction to the fundamentals, Brian D. Storey

Course Title: ME441: Manufacturing Processes

Description: Manufacturing industries are a vital component of all modern economies and all of them require employees who are skilled in, and knowledgeable about manufacturing processes. This course is designed to provide students with an overview of a wide variety of manufacturing processes. It deals with the principles, analysis, and selection of manufacturing processes. Students will understand solidification, metal forming and sheet metalworking, material removal, joining, and assembly processes. Manufacturing systems will be discussed. Design for manufacturing and manufacturing economics are introduced. Lab sections and group project will provide students' valuable hands-on experience.

Prerequisite*: Mechanics of Materials*

Objectives: By the end of this course, students should be able to:

1. Identify the different manufacturing processes based on application.
2. Explain manufacturing processes holistically using sketching and written communication.
3. Calculate basic processes parameters.
4. Select manufacturing process based on their capabilities, finishing quality, tolerance, and cost.
5. Apply manufacturing processes to a designed project.
6. Students will be able to build teams in project works.

Topics: Overview of Manufacturing, production systems and manufacturing economics, mechanical properties, fluid properties, polymer viscoelastic properties, manufacturing quality dimensions, solidification process, powder and particulate processing, metal forming and sheet metalwork, metal removal process, joining and assembly processes, and advanced manufacturing.

Mode of delivery: In-person lectures, Lab work

Textbook:

- Mike P. G. (2020). Fundamentals of Modern Manufacturing, Materials Processes and Systems (7th ed.). John Wiley and Sons, Inc.

***References*:**

- Kalpakjian, S., & Schmid, S, (2017). Manufacturing Processes for Engineering Materials (6th ed.). Pearson.

Course title: EE 451 Power Engineering

Description: This course is the study of electrical power generation and use in various industries. The course will look at how electrical energy is generated from and converted to other forms of energy. Students will study power generation systems, transmission (both AC and DC transmission, and high voltage systems), distribution systems, electrical components, electric power utilization and power quality. Students will also study how to strategically bring together power technology to make needed energy available by considering need, the environment, and sustainability.

Prerequisite: *Circuits and Electronics, Introduction to Electrical Machines and Power Electronics*

Objectives: The following objectives of the course gives the student the firm grasp of the course material namely:

1. Through this course, the student will gain a comprehensive understanding of the factors driving the development of current (modern) power systems.
2. They will gain a sound understanding of the challenges posed in operating advanced systems to achieve objectives that may conflict in some cases: reduction of the cost of electricity supply, reduction of CO2 emissions associated with power generation, and the safe utilization of current generation/modern power system facilities.
3. The students will learn to find advanced operational and control solutions based on current generation and future communication and power electronics technologies.
4. The comprehensive knowledge and analytical skills obtained can also be applied to power system planning and design studies.

Topics: Sources and forms of energy, electric power generating stations, electric power transmission (ac & dc), distribution and supply, mechanical design of overhead lines, electrical design of overhead lines, economics of power generation and performance of transmissions lines.

Mode of delivery: In-person lectures, Lab work

Textbooks: Arthur, R. B. (n.d.). Power Systems Analysis (2nd ed.).

Reference Texts:

- Mehta, V. K., & Mehta, R. (2005). Principles of Power System.
- Grigsby, L. L. (2012). Electric Power Generation, Transmission, and Distribution. CRC Press.
- Elgerd, O. I., & van der Puije, P. D. (2012). Electric Power Engineering (2nd ed.). Springer.
- Schavemaker, P. (2008). Electrical Power System Essentials. Wiley.

EE 453 Power Systems Analysis
Elective for EE and ME students
Prerequisite: Power Engineering
Credit Hours: 4; Ashesi Credit Units: 1; Hours per week classroom: 3; Hours per week discussion/lab: 1.5

This course is a study of advanced topics in electric power distribution systems planning and operation. In this course, students will learn how to analyze flows on power networks and their applications to real systems. It provides students with a working knowledge of power system problems and computer

techniques used to solve some of these problems. It also provides a technical treatment of the general problem of power system stability and its relevance. They will learn how to strategically bring together power technology to make energy available to industry by considering need, environment and sustainability. Note: EE and ME majors wishing to work in the power systems industry are advised to take *Power Engineering* and *Power Systems Analysis* as their two electives.

Topics: Network equations, and per unit system, power transformers, transmission line parameters and modeling (including induction and complex power transmission), steady state and transient operation, transformer modeling, generator modeling (machine view point and circuit viewpoint), network matrices, power flow analysis (including solution by Newton-Raphson and Gauss iteration), faults (symmetrical and unsymmetrical), system protection (elements of power system protection: protection relays, zone of protection, automatic generation control AGC etc) power system controls, transient stability, power distribution. Economic operation of power systems.

Lab Exercise: Transmission Line Modeling, transmission line with different load conditions, load flow analysis etc.

Textbook: Bergen, A. R., & Vittal, V. (2000). Power Systems Analysis (2nd ed.). Prentice Hall.

References:

- Grainger, J., & Stevenson Jr., W. (1994). Power System Analysis. McGraw-Hill.
- Grigsby, L. L. (2012). Electric Power Generation, Transmission, and Distribution. CRC Press.
- Elgerd, O. I., & van der Puije, P. D. (2012). Electric Power Engineering (2nd ed.). Springer.
- Schavemaker, P. (2008). Electrical Power System Essentials. Wiley.
- John Grainger, William Stevenson Jr., *Power System Analysis*, McGraw-Hill, 1994.
- Leonard L. Grigsby, *Electric Power Generation, Transmission, and Distribution*, CRC Press, 2012.
- Olle Ingemar Elgerd, Patrick D. van der Puije, *Electric Power Engineering*, 2nd Ed., Springer, 2012.
- Pieter Schavemaker, *Electrical Power System Essentials,* Wiley, 2008.

EE454: Renewable Energy and Smart Power Grid

Elective for EE and ME students
Prerequisite: Power System Engineering and Power Electronics
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion/lab: 1.5
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 9 per week)

A Smart Grid is the integration of numerous technologies, systems and processes with the aim to modernize and fully automate the entire electricity grid covering generation, transmission, distribution, utilization plus conservation of energy. This course introduces students to smart grids and intelligent distribution networks. Renewable energy sources and their integration in smart grids as well as energy storage technologies are discussed and these include distributed generation technologies, control technologies, modeling and storage technologies. Demand side/load management is explored, including reactive power optimization. Other topics that this course addresses are smart metering techniques, grid network security and best practices in this domain. Students will also be introduced to electric vehicles in smart grids.

Key topics include: Information and communication technologies for smart grid, Communication technologies for the smart grid, information security, Sensing, measurement, control and automation technologies: smart metering and demand-side integration, distribution automation equipment, distribution management systems, transmission system operation. Power electronics and energy storage: power electronic converters, power electronics in the smart grid, and for bulk power flows.

ENGR 442: Mechatronics Systems Design

Elective for EE and ME students

Prerequisite: Mechanics, Sensors, Control theory, Microcontrollers, Electronics, and Electrical Motors.

Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion/lab: 1.5

Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 9 per week)

Mechatronics is the synergistic integration of mechanical disciplines, controls, electronics and computers (software) in the design of high-performance machines, devices and processes. This course reviews principles in software programming, machine design, modelling of multi-domain dynamic systems, controls theory, electronics circuits, real-time controls implementation, and system-level integration. Hands-on lab exercises and projects provide extensive coverage of mechanical components, sensors, actuators, electrical drives, signal conditioning circuits, modelling and simulation tools, DAQ hardware and software (microcontrollers), and microprocessors. The main idea of the course is to review and interface the described subsystems to design fully integrated mechatronic systems that meet specified requirements.

EE442: Power Electronics

Prerequisites: Circuits & Electronics, Introduction to Electrical Machines

Description: In Power Electronics the students will study various static methods to control the power flow between source and load. Due to the high level of power, the main solution for these methods is either forced switching for transistors or naturally for diodes; the thyristors present a forced switching ON and naturally switching OFF.

This subject aims at familiarizing the student with power electronic components in terms of *how they work* and *how they are applied*. First of all the student must learn to know the operation and limitations of the different components. Secondly this course aims at creating an understanding of how these components are applied in different basic types of converters like ac-to-dc converters (rectifiers), dc-ac converters (inverters), dc-dc converters (choppers & switch-mode power supplies) and other types of power conversion methods. A basic foundation is also laid concerning the parameters with which the performance of these converters is measured.

Power Electronic converters like ac and dc drives are used more and more to control the speed and torque of ac and dc motors which are covered in subjects like Electrical Machines III & IV. The controlling of these motors by drives is used in factory processes.

Objectives: After successful completion of this course,

Students will be able to

1. Demonstrate sound knowledge of various semiconductor devices, their behavior and understanding of definition of specific parameters for power electronics and how to apply them.
2. Understanding of the operation and limitations of power semiconductor devices, an ability to calculate these limitations and also a few methods to prevent failure due to these limitations.
3. Understanding of the basic operation of uncontrolled and controlled single-phase rectifiers for ac-to-dc conversion and an ability to evaluate their performance and to do a simple design of them Design and specify renewable energy systems (e.g., solar and wind energy sources) as well as storage devices (e.g., batteries) connected to the smart grid.
4. Understanding of the operation of the basic dc-to-dc power converters and a thorough understanding of the buck regulator together with an ability to design its elements.
5. Understanding and calculation of the basic operation of single-phase and three-phase inverters for ac-to-dc conversion. Also, a basic knowledge of pulse width modulation techniques for inverters and the applications for inverters.

6. Understanding and calculation of phase control for cycloconverters, AC and DC drives and static switches, but also integral cycle control for the latter in order to do power control on various loads. Also a basic understanding of how static switches and transistors are used as DC switches
7. Present standards related to the development and efficient operation of smart grids,
8. Classify the cybersecurity vulnerabilities and understand the risks of an attack on the grid.

Topics: Power Electronics Devices, Applications, Limitation of semiconductor devices and methods to prevent their failure, AC-to- DC Power Conversion, DC-to- DC Power Conversion (Choppers); DC-to- AC Power Conversion (Inverters), Control of Power Conversion in Power Electronics.

Textbooks:

- Mohan, N., Underland, T. M., & Robbins, W. P. (2002). Power Electronics: Converters, Applications and Design. Wiley.
- Rashid, M. H. (2011). Power Electronics: Devices Circuits and Applications. Wiley.

Reference:

- Open source text book excerpts and scientific journal articles specific for the topics.
- Interactive webcast and lectures will be suggested prior to the class.

Mechanical Engineering Electives

ME 432 Computational Fluid Dynamics

Prerequisite: Fluid Mechanics

Description: This course provides students with an in-depth understanding of thermal-fluid science and its application in solving problems. The course will introduce students to how to model thermofluid problems, write simple computer programming codes, and use basic computational/numerical tools to solve engineering problems. The course will cover computational simulations using MATLAB, SolidWorks, and Ansys Workbench.

Objectives: By the end of this course, students should be able to:

1. Understand the theories of fluid mechanics and heat transfer.
2. Model differential equations for fluid and heat transfer problems.
3. Write programming codes to solve basic fluid problems.
4. Solve advance fluid and heat transfer problem using computational tools.
5. Analysis computational solutions and compare result to other approach of solving fluid problem (Experimental and Analytical).

Topics: MATLAB: Modeling Engineering Problems; SolidWorks: Modeling Flow and Heat Transfer Problems; Ansys: Basic Fluid Flow Compressible Flows, Turbulence flow, Heat Transfer and Heat Exchangers, Combustion mixtures, Multiphase Flows

Textbooks:

- Fluid Mechanics, 8th Edition, Frank M. White, McGraw Hill.

References:

- ANSYS Inc., (2023) ANSYS Fluent Tutorial Guide (pp. 1-1684), Southpointe: 2600 Technology Drive.
- Mentor Graphics, 2012. SolidWorks Flow Simulation Tutorial (pp. 1-266).
- ANSYS Inc., (2023) ANSYS Fluent User's Guide (pp. 1-6098), Southpointe: 2600 Technology Drive.
- ANSYS Inc., (2023) ANSYS Fluent in ANSYS Workbench User's Guide (pp. 1-124), Southpointe: 2600 Technology Drive.
- ANSYS Inc., (2023) ANSYS Fluent in Theory Guide (pp. 1-1112), Southpointe: 2600 Technology Drive.
- Misza Kalechman, (2018) Practical MATLAB for Engineers (pp. 1-708). New York: Taylor and Francis.

ME412 Advanced Thermodynamics

Prerequisite: Thermodynamics

Course description
This course is an applied aspect of thermal science and engineering. It is designed to introduce students to the design, analysis and implementation of thermal systems. Students will apply the principles of thermodynamics to the operation of different thermal systems including thermal power generation, conventional automobile engine power operations, refrigeration, psychrometry and air conditioning processes, fuels and combustion processes. students will also be introduced to non-conventional and utilization of energy resources and energy management.

Objectives:
After successful completion of this course, students will be able to:

1. Appreciate and apply the exergy and exergy principles to performance of engineering systems.
2. understand and apply the laws of thermodynamics to generation.
3. understand and apply the laws of thermodynamics to the design of refrigeration systems.
4. Understand psychrometry and its application to air conditioning processes and systems.
5. Appreciate the principle of reactive mixtures and combustion of fuels.
6. Understand and apply the principles of thermodynamics to combustion of fuels.
7. Develop fundamental relations among thermodynamic properties.
8. Discuss non-conventional energy resources and their utilization and management.

Topics: exergy and work potential, gas power cycles, vapour and combined power cycles, refrigeration cycles, thermodynamic property relations, gas mixtures, psychrometry and air conditioning processes, reactive mixtures, non-conventional energy resources, utilization and management***.***

Labs: marcet boiler module, orsat apparatus, gas turbine module, steam turbine module, IC engine module, heat pump module, simulations (MATLAB, EES, TEST).

Textbook:

- Yunus A. Çengel, Michael A. Boles, Thermodynamics: An Engineering Approach, 9 th ed., McGraw-Hill, 2018.

Reference text:

- Michael J. Moran, Howard N. Shapiro, Daisie D. Boettner, Margaret B. Bailey, (2018) Fundamentals of Engineering Thermodynamics, 9th ed., Wiley
- R. K. Rajput (2010), Engineering Thermodynamics, 4th ed., Laxmi
- T.D. Eastop and A. McConkey, (1993) Applied Thermodynamics for Engineering Technologists, 5th ed., Longman.

ME 423 Refrigeration and Air-conditioning

Prerequisite: Heat transfer

Course description:
This course a specialized area in thermal engineering. It is designed to expose students to the field of heating, ventilation, air conditioning and refrigeration (HVACR) principles, processes and systems. It is treated in two parts, Refrigeration Engineering, followed by Air Conditioning Engineering. Each part begins with introduction of the basic theory of the subject and thereon to the practical system and its components with the aim of equipping the student sufficient background to pursue a future career in the HVACR profession. This course advances on the theory behind refrigeration and air conditioning and brings the student closer to the practical systems.

Objectives:
After successful completion of this course, students will be able to:

1. Explain the effect of refrigeration and air conditioning processes.
2. Identify and explain various refrigeration cycles.
3. Identify practical domestic and commercial refrigeration and air conditioning systems/ plants, plant accessories and their respective roles in the system.
4. Carry out basic design of refrigeration and air conditioning systems for specific applications.
5. carry our load estimation, size and select plant components.
6. Supervise the installation, operation, servicing, troubleshooting, and maintenance of refrigeration and air conditioning systems.
7. Perform and report on energy audit of HVACR systems.

Topics: Theory of heat, introduction to refrigeration principles and the second law of thermodynamics, refrigeration cycles, components of refrigeration systems/plants, refrigeration system components control, refrigerants and thermal insulations, refrigeration load estimation, introduction to psychrometry and air conditioning, air conditioning processes, types of air conditioning systems, air conditioning load estimation, tubing, piping and duct design and considerations, HVACR installation, operation and maintenance, energy audit and reporting of HVACR system. Modern technologies in HVACR systems.

Labs: evaporation of volatile liquids, refrigeration operation module, air conditioning operation module, simulations (MATLAB, EES, TEST).

Textbook

- A.R. Troth and T.C. Welch, Refrigeration and Air conditioning, 8th ed., Butterworth-Heinemann
- Whitman, B., Johnson, B., Tomczyk, J., & Silberstein, E. (2017). Refrigeration and Air Conditioning Technology. Cengage Learning.

References

- Yunus A. Çengel, Michael A. Boles, Thermodynamics: An Engineering Approach, 9 th ed., McGraw-Hill, 2018.
- Althouse, A. D., Turnquist, C. H., Bracciano, A. F., & Bracciano, D. C. (2016). Modern Refrigeration and Air Conditioning. Goodheart-Willcox.
- Pita, E. G. (2017). Air Conditioning Principles and Systems: An Energy Approach. Pearson.
- Wang, S. K. (2017). Handbook of Air Conditioning and Refrigeration. McGraw-Hill Education.
- Stanfield, C., Skaves, D., & AHRI. (2016). Fundamentals of HVAC/R. Pearson.

ME 402 Advanced Mechanical Machine Design

Description: This course builds on Mechanical Machine Design (ME 301) and covers the principles and current practices of design and selection of various machine elements, including solid modeling and finite element analysis (FEA). The elements include gears, springs, keys and seals, belt drives, chain drives, screws, fasteners, nonpermanent joints, clutches, brakes, coupling, flexible mechanical elements, flywheel, welding, bonding, and design of permanent joints.

Prerequisite: *Mechanical Machine Design*

Objectives: After successful completion of this course, students will be able to

1. Perform load analysis of different components in a mechanical system.
2. Design mechanical elements based on static and fatigue failure theories.
3. Use engineering techniques, skills and modern engineering tools necessary for engineering practice.
4. Model a mechanical system with CAD software such as SolidWorks.
5. Conduct stress, deflection, vibration, and impact analyses of mechanical elements and assemblies using finite element method (FEA) software.

6. Conduct design optimization using a FEA software.

Mode of delivery: In-person lectures, Lab work

Topics**:** Gears and Gearing (Spur, Helical, Bevel and Worm), Keys and Seals, Springs, Lubrication, Reliability, Belt Drives and Chain Drives, Screws (e.g., Power Screws), Fasteners, Nonpermanent Joints (e.g., Bolted Joints), Hub-shift Joints, Clutches, Brakes, Coupling Systems, Torque Converters, Linear Motion Elements, Flywheel, Flexible Mechanical Elements, Welding, Bonding, and Design of Permanent Joints.

Textbook: Richard G. B., & Keith, J. N. (2015). *Mechanical Engineering Design* (10th ed.). Shigley's.

Reference**:**

- Robert, M. (2013). Machine Elements in Mechanical Design (5th ed.). Prentice Hall.
- Jack, C., Henry, B., & George, S. (2009). Mechanical Design of Machine Elements and Machines, (2nd ed.). Wiley.
- Theodore, W. (2006). Electrical Machines, Drives and Power Systems (6th ed.). Pearson Higher Education.
- Erik, O. (2012). Machinery's Handbook (29th ed.)., Industrial Press.
- Michael, R. L. (2013). Mechanical Engineering Reference Manual, Professional Publications.

ME 444: Advanced Manufacturing Processes

Description This course builds on Manufacturing Processes (ME 441) and covers theory, application, and design considerations in manufacturing processes, including: solidification processes (glass-working, shaping processes for plastics, and processing of polymer matrix composites and rubber), processing of ceramics and cements, material removal processes (power and energy in machining, cutting-tool technology, economic and product design considerations in machining, and grinding and other abrasive processes), surface processing operations, joining and assembly (fundamentals of welding, welding processes, brazing, soldering, and adhesive bonding, mechanical assembly), special processing and assembly technologies (rapid prototyping and additive manufacturing, processing of integrated circuits, and electronics assembly and packaging), manufacturing systems (automation technologies for manufacturing systems and integrated manufacturing systems), and manufacturing support systems (process planning and production control and quality control and inspection). Also, machines and tooling, machine tools design, dimensional and tolerances analyses, design of jigs, fixtures, and tools in modern manufacturing processes will be covered. Machine shop and factory design will be introduced.

Prerequisite*: Manufacturing Processes*

Objectives: By the end of this course, students should be able to:

1. To recognize the parameters that influence various manufacturing processes and to analyze the effects of these parameters on the characteristics of a given process.
2. Determine a set of feasible processes to produce a given part.
3. Perform stress analysis in forming and machining operations to determine safe operating limits.
4. Evaluate the power required to produce a part by machining or forming.
5. Identify the process parameters that affect the product quality and process performance.
6. Select the appropriate process parameters to optimize a process.

Topics: Manufacturing processes to be selected from: solidification processes (glass-working, shaping processes for plastics, and processing of polymer matrix composites and rubber), processing of ceramics and cements, material removal processes (power and energy in machining, cutting-tool technology, economic and product design considerations in machining, and grinding and other abrasive processes), surface processing operations, joining and assembly (fundamentals of welding, welding processes, brazing, soldering, and adhesive bonding, mechanical assembly), special processing and assembly technologies (rapid prototyping and additive manufacturing, processing of integrated circuits, and electronics assembly

and packaging), manufacturing systems (automation technologies for manufacturing systems and integrated manufacturing systems), and manufacturing support systems (process planning and production control and quality control and inspection). Machines and tooling, machine tools design, dimensional and tolerances analyses, design of jigs, fixtures, and tools. Machine shop and factory design.

Mode of delivery: In-person lectures, Lab work

Textbook:

- Mike P. G. (2020). Fundamentals of Modern Manufacturing, Materials Processes and Systems (7th ed.). John Wiley and Sons, Inc.

***References*:**

- Kalpakjian, S., & Schmid, S, (2017). *Manufacturing Processes for Engineering Materials* (6th ed.). Pearson.

ME 461: Composite Design and Fabrication

Description This course provides knowledge on the fabrication of different types of composites, and the understanding of the dependence of their behaviour on the characteristics, relative amounts, geometry/distribution, and properties of the constituent phases. It seeks to equip students to be able to select and combine different engineering materials based on their properties to maximize their durability and performance. The possibility of designing materials with property combinations that are better than those found in any monolithic metal alloys, ceramics, and polymeric materials will also be explored.

Prerequisite*: Materials Science & Chemistry*

Objectives: By the end of this course, students should be able to:

1. Expose the students to various composites available and their manufacturing methods.
2. Know about the properties, classification and applications of composites in the industries:
3. Understand the Manufacture of composites.
4. Fabricate structural panels with fiber reinforced polymer matrix composites.
5. Measure mechanical properties under different stress states and in different directions.
6. Check the quality of the composite parts.

Topics: Fabrication of different types of composites, dependence of their behaviour on the characteristics, relative amounts, geometry/distribution, and properties of the constituent phases. Select and combine different engineering materials based on their properties to maximize their durability and performance. The possibility of designing materials with property combinations that are better than those found in any monolithic metal alloys, ceramics, and polymeric materials.

Mode of delivery: In-person lectures, Lab work

Textbook:

- Ever J. B., (2017). Introduction to Composite Materials Design, 3rd Edition, 2017. https://doi.org/10.1201/9781315296494, e-ISBN-9781315296494, Boca Raton, CRC Press.

***References*:**

- Callister, W. D., & Rethwisch, D. G. (2018). Materials science and engineering: an introduction (Vol. 9). New York: Wiley.
- Chawla K. K (1993) Ceramic Matrix Composites. London: Chapman & Hall, 1993.
- Hull D and Clyne T. W (1996). An Introduction to Composite Materials, 2nd Ed., Cambridge Press, 1996.
- Joachim R., Harald H., & Martin B., (2007) Mechanical Behaviour of Ceramic, Polymer, Composites (ISBN 978-3-540-73446-8 Springer Berlin Heidelberg New York).
- Morley J. G (1987) High Performance Fibre Composites. London: Academic Press, 1987.

- Soboyejo, W. (2002).Mechanical properties of engineered materials (Vol. 152). CRC press.
- Wanberg, J. (2018). Composite Materials Bible, Wolfgang Publications Incorporated.

ME 445: Machine Shop & Factory Design

Description This introductory course deals with choosing location for industrial plants, machine shop and factory designs. It also covers Planning the layout of the shop or factory to avoid unnecessary handling. Batch production, line-flow production. Handling work at machine; moving work about the shop: transport conveyors and work handling appliances - gravity, chain, and belt conveyors, hoists, cranes, trucks. Work flow; plant capacity. Storing materials and finished products. Tool rooms; accessibility of tool rooms. Tool room layouts, Industrial ventilation, lamination, quality and quantity, lighting design and economics. Sound, noise and ultrasonic noise control and applications. Accidents prevention, mechanical guarding of machines. Electrical equipment; occupational hazard and fire protection.

Prerequisite*: Manufacturing Processes*

Objectives: By the end of this course, students should be able to:

1. Introduce students to machine shop and factory designs.
2. Plan the layout of the shop or factory, etc.

Topics: Choosing location for industrial plants, machine shop and factory designs. Planning the layout of the shop or factory to avoid unnecessary handling. Batch production, line-flow production. Handling work at machine; moving work about the shop: transport conveyors and work handling appliances - gravity, chain, and belt conveyors, hoists, cranes, trucks. Workflow; plant capacity. Storing materials and finished products. Tool rooms; accessibility of tool rooms. Tool room layouts, Industrial ventilation, lamination, quality and quantity, lighting design and economics. Sound, noise and ultrasonic noise control and applications. Accidents prevention, mechanical guarding of machines. Electrical equipment; occupational hazard and fire protection.

Mode of delivery: In-person lectures, Lab work

Textbook:

- Hirano, H. (1989). JIT Factory Revolution: A Pictorial Guide to Factory Design of the Future. (1st Ed). Productivity Press.

***References*:**

- Moltrecht, K. (1981). Machine Shop Practice (Vol. 1, 2nd Ed). Industrial Press, Inc.
- Reinertsen, D. (1997). Managing the Design Factory: The Product Developer's Toolkit. The Free Press.
- Rose, J. (1901). Modern Machine Shop Practice: Modern Machine-Shop Practice; Operation, Construction, and Principles of Shop Machinery, Steam Engines, and Electrical Machinery. New York, Charles Scribner's Sons.
- Uffelen, C. V. (2008). Factory Design. Braun.

ME 433: Gas Dynamics and Jet Propulsion

Description: This course introduces students to the basic concepts and importance of gas dynamics and jet propulsion. Areas to consider include basic concepts and isentropic flows: energy and momentum equations of compressible fluid flow, stagnation states, Mach waves and Mach cone-effect of Mach number on compressibility; Flow through ducts: flows through constant area ducts with heat transfer (Rayleigh flow) and friction (Fanno flow), variation of flow properties; Normal and oblique shocks: governing equations, variation of flow parameters across the normal and oblique shocks, Prandtl-Meyer relations, Applications; Jet propulsion - theory of jet propulsion, thrust equation, thrust power and

propulsive efficiency; Space propulsion: types of rocket engines, propellants feeding systems, ignition and combustion, etc.

***Prerequisite**: Fluid Mechanics*

Objectives: By the end of this course, students should be able to:

1. Understand how the flow takes place in flow and non-flow systems; to understand the phenomena of shock, Fanno, and Rayleigh flow.
2. Know the differences between compressible and incompressible flows.
3. Solve problems in Rayleigh and Fanno flow.
4. Understand the knowledge about the rocket propulsion and various propellants.
5. Analyze Jet Propulsion Cycle.
6. Determine flow parameters found in high speed flow through nozzles and/or diffusers
7. Analyze Rocket Propulsion Cycle.
8. Analyze typical combustion processes to perform energy balances and determine heat release from chemical reactions.

Topics: Basic concepts and isentropic flows: energy and momentum equations of compressible fluid flow, stagnation states, Mach waves and Mach cone-effect of Mach number on compressibility; Flow through ducts: flows through constant area ducts with heat transfer (Rayleigh flow) and friction (Fanno flow), variation of flow properties; Normal and oblique shocks: governing equations, variation of flow parameters across the normal and oblique shocks, Prandtl-Meyer relations, Applications; Jet propulsion - theory of jet propulsion, ideal gas flow, jet propulsion cycle, nozzles, thrust equation, thrust power and propulsive efficiency; Space propulsion: types of rocket engines, liquid rockets, propellants feeding systems, ignition and combustion processes, etc.

Mode of delivery: In-person lectures, Lab work

Textbook:

- Anderson, J. D. (2013). Modern Compressible Flow (3rd Ed). New York: McGraw Hill Education.

***References*:**

- Kannan, K. (2012). Gas Dynamics and Jet Propulsion. Chennai: Anuradha Publications.
- Mishra, D. P (2015). Gas Turbine Propulsion. New Delhi:Viva Books Private Limited.
- Pandian, K., Anderson, A. & Ramachandran, S. (2016). Gas Dynamics and Jet Propulsion (3rd Ed). Chennai: Airwalk Publications.
- Sforza, P. (2011). Theory of Aerospace Propulsion. Oxford: Butterworth-Heinemann.
- Sutton, G. P. & Biblarz, O. (2017). Rocket Propulsion Elements (9th Ed). Hoboken: John Wiley and Sons.

ME 443: Renewable and Non-renewable Energy Systems

Description: This course introduces renewable and non-renewable energy systems, with a scientific scrutiny of the energy field and an emphasis on alternate energy sources and their technology and application. The course will explore our society's present needs and future energy demands, review conventional energy sources and systems, including fossil fuels and nuclear energy, and then focus on alternate, renewable, and non-renewable energy sources.

***Prerequisite**: None*

Objectives: By the end of this course, students should be able to:

1. Have knowledge about various renewable energy sources.
2. Have knowledge about various nonrenewable energy sources.
3. Appy CAD package for design and simulation.
4. Compare and contrast various sources of energy, etc.

Topics: Introduction (energy, energy landscape, energy systems, and sustainability, energy sources, demands, energy conversion, and environment impact, including renewable and non-renewable energy); renewable energy and their conversion to fuels, heat and work; grid integration of renewable energy; solar energy, including characteristics and availability of solar radiation, photo-voltaic conversion, sizing of PV components for DC and AC loads; thermal design of flat plate collectors and application to air heating, water heating, distillation, etc.; water power (hydro, tidal and wave); and ocean thermal energy conversion, tides, and wave energy conversion; geothermal energy; bioenergy (biomass, biofuels); nuclear energy; wind energy and wind energy conversion; renewable energy and energy efficiency in buildings; energy storage and transmission; involvement of emerging technologies such as artificial intelligence (AI) and internet of things (IoT); Project on applications.

Mode of delivery: In-person lectures, Lab work

Textbook:

- Dunlap, R. A. (2020). Renewable Energy (Synthesis Lectures on Renewable Energy Technologies). Morgan & Claypool.

***References*:**

- Ehrlich, R., & Geller, H. A. (2018). Renewable Energy: A First Course (2nd Ed). Boca Raton: CRC Press, Taylor and Francis.
- Heshmati, A., Abolhosseini, S. & Altmann, J. (2015). The Development of Renewable Energy Sources and its Significance for the Environment. New York: Springer Singapore Heidelberg.
- Ghosh, T. K. & Prelas, M. A. (2009). Energy Resources and Systems: Volume 1: Fundamentals and Non-Renewable Resources. Springer.
- Ghosh, T. K. & Prelas, M. A. (2011). Energy Resources and Systems: Volume 2: Renewable Resources. Springer.
- Jones, L. E. (2017). Renewable Energy Integration: Practical Management of Variability, Uncertainty, and Flexibility in Power Grids (2nd Ed). Academic Press.
- Maddie, S. (2018). The Science of Wind Energy. San Diego: Reference Point Press Inc.
- Murez, W. & Alboom, E. V. (2019). The ABC of the Climate Future: On Climate, Biodiversity, Renewable Energy and the Environmental Movements. Werner Murez.
- Schaeffer, J. (2014). Real Goods Solar Living Sourcebook: Your Complete Guide to Living Beyond the Grid with Renewable Energy Technologies and Sustainable Living (14th Ed). Gabriola Island: New Society Publishers.
- Strezov, V. & Anawar, H. M. (2019). Renewable Energy Systems from Biomass Efficiency, Innovation, and Sustainability. Boca Raton: CRC Press, Taylor and Francis.

ME 453 Automotive Engineering

Prerequisite: Mechanics of Machines

Description: This course provide students with knowledge and understanding of basic principles on which automobiles function. Students will be introduced to the various components of automobiles (Power House, Clutch, Transmission, Drive Line Suspension, Steering, Brakes, Wheel and Tyres, Emission Control, Electricals, etc.) their working principles. The course will also introduce maintenance, safety regulations, workshop practice and equipment used in the automobile industry. There will be practical and workshop for students to gain hands-on experience in the automobile industry. Finally, students will be acquainted with modern issues facing automotive engineering.

Objectives: By the end of this course, students should be able to:

1. Have knowledge on the overview of Automotive Engineering.
2. Identify and know the working principles of the major components of an Automobile. Design to select some components of an Automobile.

3. Diagnose and repair basic faults.
4. Have knowledge on current trends and technology in Automotive engineering.

Topics: Introduction to Automotive Engineering, Power House (Introduction to Engines, Overview of Cycles, Components of an Engine, Transmission (Clutch, Gearbox and Driveline), Steering Systems, Suspension Systems, Brakes, Wheels and Tyres, Electrical and Emission Control Systems Fuel Supply Systems, Fuel Supply Systems, Air Conditioning, Cooling and Lubrication Maintenance and Service, Maintenance and Service, Advanced Vehicle Technologies

Textbooks

- Tom Denton (2011), Automobile Mechanical and Electrical System, Elsevier
- Vashisth, D. and Ahmad, M. (2017), Automobile Engineering, I. K. International Publishing House
- Miller, J. D. (2020), Automotive System Safety: Critical Considerations for Engineering and Effective Management, 1st Edition, Wiley
- Feroz, N. (2019), Automobile Engineering: Textbook for Engineering Students, Independently published
- Sakthivel, R., Mahroogi, F. O., Narayan, S., Abudbaker, S., Kaisan, M. U. and Alammari, Y. (2019), Introduction to Automotive Engineering, Wiley
- Halderman, J. (2015), Automotive Technology: Principles, Diagnosis, and Service, 5th Edition, Pearson
- Erjavec, J. and Thompson, R. (2014), Automotive Technology: A Systems Approach, 6th Edition, Cengage Learning

ME 451 – Aerospace Projects

Prerequisites: Fluid Mechanics

Description:

How does one design and build aerospace systems? This course is an overview of aerospace engineering, covering the major topics on which analysis must be carried out. This includes aerodynamics, aircraft performance, aerospace materials and their structural properties, flight dynamics, and stability and control. Students will learn analytical approaches in each of these topics and then apply them to the design of real aerospace systems. The lab sessions will be used to cultivate relevant fabrication skills, measure aerodynamic and material properties, and build and test prototypes. Three different aerospace systems will be built in the course, and the last one serves as a final project that will be a team-based vehicle design competition.

Objectives:

After successful completion of this course, students will be able to

1. Effectively work in teams in a systems-level approach to design and build real aerospace projects.
2. Understand the fundamentals of aerodynamics, aerospace structures, aerospace propulsion, and stability and control.
3. Identify the main components of an aircraft and technically explain their contributions.
4. Determine aircraft performance and flight envelope, based on aircraft morphology, lift and drag calculations, and engine data.
5. Accurately size the main components of an aerospace system.
6. Carry out structural analysis on the aircraft's primary load carrying members.
7. Determine basic structural properties of typical aerospace materials, including composites.
8. Apply the concept of static stability to flight vehicles.
9. Apply equations of motion to determine aircraft performance in gliding, horizontal and climbing flight.

10. Command basic aerospace fabrication skills, including foam cutting and lay-up of composite materials.
11. Identify current trends in aerospace engineering and highlight points of opportunity for the African context.

Topics:

This course covers the fundamentals of major aerospace engineering topics. It begins with an introduction to flight- its history and basic principles. Nomenclature for relevant parameters and aircraft parts are described. A review of fluid mechanics is used to lead into aerodynamics, covering lift and drag, boundary layers, airfoil theory, etc. Characterization of aircraft performance is covered next, describing parameters such as operable range, endurance, and covering the V-n diagram. A foray into common aerospace materials, including composites, and the associated structural analysis is done next. Aerospace propulsion including propellers, jet engines, power ratings is covered next. Finally, the equations of motion are used to study flight dynamics and basic stability and control analysis. Given the breadth of topics relevant to this course, each student's personal interest in the subject may find emphasis in different areas. To enhance this interest and practice communication skills, the last few lectures will be reserved for student presentations on aerospace topics of their choosing.

The laboratory sessions will be used to implement aerospace systems design skills. They will cover a range of fabrication skills building, aerodynamics experiments, materials characterization. In total, the students will design and build three distinct aerospace systems. The final system (a Lighter-than-Air Vehicle) will be carried out as a group project, culminating in a competition and design presentation.

Topics include Introduction, History of Flight, Aircraft Parts & Configurations, Nomenclature, Physical Properties of Air, Standard Atmosphere, Fluid Mechanics Review, Aerodynamics, Aircraft Performance, Aerospace Structures, Aerospace Materials, Aerospace Propulsion, Flight Dynamics, Stability & Control.

Labs: The drop test, Fabrication Techniques: cutting card and foam, Glider flight, Lift and drag, Fabrication Techniques: composite lay-ups, Model Rocket, Sensor packaging and payload design

Textbook

- Matthews, Clifford (2002) "Aeronautical engineer's data book."
- Soler, Manuel (2017) "Fundamentals of Aerospace Engineering," 2nd Edition

Reference

- Anderson, John. "Introduction to Flight", 7th Edition

ENGR 444: Automation and Production Systems

Prerequisite: Manufacturing Processes

Course Description: This course provides students with up-to-date coverage of production systems, how they are sometimes automated and computerized, and how they can be mathematically analyzed to obtain performance metrics. The course is designed primarily for engineering students at the advanced undergraduate or beginning graduate levels in industrial, mechanical, and manufacturing engineering, who wish to learn about automation and production systems technologies in modern manufacturing. Students will also be exposed to computer-integrated manufacturing.

Objectives:

After successful completion of this course, students will be able to:

1. Illustrate the basic concepts of production systems and automation in machine tools.
2. Understand the technical and engineering aspects of automated production systems.
3. Categorize the major forms and systems for automated production and automated assembly lines.

4. Analyze various automated flow lines, explain assembly systems, and line balancing
5. methods.
6. Describe the importance of automated material handling and storage systems.
7. Interpret the importance of control systems, automated inspection systems.
8. Understand the manufacturing systems.
9. Understand the quality control systems.
10. Understand the manufacturing support systems and computer-integrated manufacturing.
11. Expose to various tools such as Factory I/O, PLC, SCADA, Tacton Design Automation, etc.

Topics: Topics will be selected from the following areas: Introduction to Automation and Production Systems, Overview of Manufacturing (Manufacturing Operations, Manufacturing Metrics and Economics), Automation and Control Technologies (Introduction to Automation, Industrial Control Systems, Hardware Components for Automation and Process Control, Computer Numerical Control, Industrial Robotics, and Discrete Control and Programmable Logic Controllers), Material Handling and Identification (Material Transport Systems, Storage Systems, and Automatic Identification and Data Capture), Manufacturing Systems (Overview of Manufacturing Systems, Single-Station Manufacturing Cells, Multi-Station Manufacturing Systems: Manual Assembly Lines, Multi-Station Manufacturing Systems: Automated Production Lines, Automated Assembly Systems, Group Technology and Cellular Manufacturing, and Multi- Station Manufacturing Systems: Automated for Flexibility), Quality Control Systems (Quality Programs for Manufacturing, Inspection Principles and Practices, and Inspection Technologies), Manufacturing Support Systems and Computer-Integrated Manufacturing (Product Design and CAD/CAM in the Production System, Process Planning and Concurrent Engineering, Production Planning and Control Systems, and Just-in-Time and Lean Production).

Lab exercises: These will be hands-on activities, that will include Factory I/O, Programmable Logic Control (PLC) and Supervisory Control and Data Acquisition (SCADA) Training, Tacton Design Automation, Manufacturing Operations, Sensors, Actuators, Manipulators, etc.

Textbook:

- Groover, M. P. (2019). Automation, Production Systems, and Computer-Integrated Manufacturing (5th Edition). Pearson.
- Reference:
- Foster, R. (2019). Automation, Production Systems and Computer-Integrated Manufacturing. Larsen and Keller Education.
- Niggemann, O. & Schuller, O., (2018). IMPROVE - Innovative Modelling Approaches for Production Systems to Raise Validatable Efficiency: Intelligent Methods for the Factory of the Future (1st Edition). Springer Vieweg.
- Ramachandran, S. and Rajan, A, J. (2016). Computer Integrated Manufacturing Systems. Mylapore: AirWalk Publications.
- Cheng, S. C. (2017). Computer-Aided Control Systems Design: Practical Applications Using MATLAB and Simulink. Boca Raton: CRC Press.
- Groover, M. P. (2016). Fundamentals of Modern Manufacturing: Materials, Processes and Systems (6th Edition). Hoboken: John Wiley and Sons.

Electrical Engineering Electives

EE 421 Digital and Analog Signal Processing in Telecommunications
Elective for CE and EE students
Prerequisite: Communication Systems
Credit Hours: 4; Ashesi Credit Units: 1; Hours per week classroom: 3; Hours per week discussion/lab: 3

This course includes the study of signal processing and technology used in the telecommunication industry. Students will study various digital and analog signal processing techniques. Starting from the basic definitions of a discrete-time signal, through Fourier analysis, filter design, sampling, interpolation and quantization, more advanced tools are studied to aid the study and design of digital communications systems. Note: CE and EE students wishing to work in the telecommunications industry are advised to take *Digital and Analog Signal Processing in Telecommunications* as one of their electives.

Topics: Discrete time signals and systems; transform analysis of linear time invariant systems, z-transforms, sampling of continuous-time signals, structures for discrete-time systems, Fourier transforms, fast Fourier transforms, computation of the discrete Fourier transform, Fourier analysis of signals using the discrete Fourier transform, signal averaging, signal compression, convolution, parametric signal modeling, discrete Hilbert transforms filters, complex techniques, and applications of all of these.

Lab Exercise: Signal processing, spectrum analysis.

Textbook: Oppenheim, A. V., & Schafer, R. W. (2010). Discrete-Time Signal Processing (3rd ed.). Pearson..

***References*:**

- Lyons, R. G. (2010). Understanding Digital Signal Processing (3rd ed.). Prentice Hall.
- Smith, S. (2002). Digital Signal Processing: A Practical Guide for Engineers and Scientists (3rd ed.). Newnes.
- Prandoni, P., & Vetterli, M. (2008). Signal Processing for Communications. EPFL Press.
- Ifeachor, E.C., & Jervis, B.W. (2001). Digital Signal Processing: A Practical Approach (2nd ed.). Prentice Hall.

CS 432 Networks & Data Communications
Required of CE, CS, and MIS majors, elective for EE and ME majors
Prerequisite: Computer Programming
Credit Hours: 4; Ashesi Credit Units: 1; Hours per week classroom: 3; Hours per week lab: 1.5

Description: This course introduces students to the fundamental concepts of computer networks and data communications, with practical applications; students will be able to recognize the components, relevance, advantages, and disadvantages of networking computers. Students will be introduced to the principles of data communications and transmission. Protocols employed in layers 1 to 3 will be examined in depth. Layer 4 protocols will be highlighted and compared to layer 2.

Methods and mechanisms for constructing distributed computing systems and network services are discussed in the context of common Internet systems such as electronic mail, print and file servers and Web services.

Hands-on exercises are used to help reinforce the fundamental concepts learnt. Labs will cover typical network operations tasks. Students will review hardware used in practice, common topologies and set up services on typical enterprise networks.

Prerequisite:

Objectives: After successful completion of this course, students will be able to:

1. Understand and appreciate data communication and networking principles.
2. Build a moderately sized computer network; for example, to implement local area networks (LANs).
3. Set up and administer network services and to analyze wide area networks (WANs).
4. Explain the operation of protocols at the different layers of the OSI work, with an understanding of data transmission using network simulation and capturing tools.
5. Compare and make appropriate protocol choices. 6. Evaluate and assess wired and wireless transmission media and applications.

Topics:

- Physical Layer-Signals, Signal Encoding techniques, transmission media, etc.
- Data Link Layer –Logical link Control (LLC) and Medium Access Control (MAC)
- Network Layer–IP Addressing, Routing, etc.
- Transport Layer–TCP, UDP and Sockets
- Application Layer
- Introduction to Network Security

Data communication topics will typically be covered under the Physical and Data Link Layers. Application protocols will be tackled in the context of Labs and technology research.

Mode of delivery: In-person lectures, discussion sessions

Textbook: Forouzan, B.A., (2013), *Data Communications & Networking*, 5E (Global Edition), McGraw-Hill

***Supplementary texts*:**

- Stallings, W., (2017), Data & Computer Communications, 10th Edition, Pearson.
- Comer, D. E., (2015), Computer Networks and Internets, 6E (Global Edition), Pearson.
- Kurose, J.F., & Rose, K.W, Computer Networking: A Top-Down Approach, 6th Edition, Pearson.
- Tanenbaum, Andrew S., & Wetherall, David J. (2011) Computer Networks, 5th Edition, Pearson.

EE 422 Advanced Communication System

Description: The course will describe the protocols used in current networks. It will provide skills needed in designing and deploying efficient and effective data communications and network technologies. This course will also develop understanding of some fundamental concepts of information theory, as well as techniques used to model and analyze communication networks. It will briefly highlight how to develop analytical tools and conceptual models for modeling and analyzing network performance. Subtopics will include Fairness and network utility maximization, Optimization based routing and congestion control, Basic queueing models and their application to switching and scheduling in networks.

Required of Advanced Communication Systems. Prerequisite: Communication Systems

Objectives: After successful completion of this course, Students will be able to

- Understand the various blocks that constitute a digital communication system and understand how they interrelate.
- Be able to analyze and evaluate digital communication systems qualitatively and quantitatively.
- Recognize the broad applicability of digital communication systems in society.
- Use software tools to analyze, design and evaluate digital communication systems.

Topics:

Wireless communication, Cellular Telephone Concepts, Multiple Access – FDMA, TDMA, CDMA, SDMA, Mobile Communication – GSM, GPRS, GPS, Bluetooth. Digital Radio Modulation Techniques: QPSK, QAM, OFDM. Telecommunication Networks: PSTN and IP Radio Access Networks, Advanced Topics in IP Networks and Switching, Wireless LAN, Mobile Ad-hoc Networks. Fiber Optic Communication and Network: Block Diagram of an Optical Fiber Communication System, Optical fiber Types and Fiber Configuration, Losses in optical fiber cables, Light Sources and Detectors, Optical fiber System Link. Satellite communications: Kepler's Laws and Satellite Orbits, Geosynchronous Satellites, Satellite Orbits, Satellite System Link Models.

Lab:

MATLAB and MATLAB Simulation, Simulation of QPSK, QAM, BPSK, MATLAB Programs for QPSK, Simulation of optical fiber communication model and satellite communication link.

Textbook:

- 1. Tomasi, Advanced Electronic Communication Systems, 6/e, Pearson, 2015

Reference:

- Jochen Schiller, Mobile Communications, Pearson, 2008.
- Mishra, Wireless communications and Networks, McGraw Hill, 2/e, 2013.
- T.L. Singal, Wireless communications, Mc Graw Hill, 2010.
- W.C.Y.Lee, Mobile Cellular Telecommunication, McGraw Hill, 2010.

Course title: CE 458 Internet of Things

Description: The Internet of Things (IoT) course takes an end-to-end view of IoT and tackles the devices, networks, data analytics, programming, security, and business aspects. This holistic approach exposes the student to all aspects of a functional IoT system and how to design robust, scalable and a secure IoT network. Labs and small projects will be used to gain understanding of key concepts at the various layers and drive a handson experience. Key among these are the devices, network protocols, database, and programming aspects. Students will review hardware types and software tools and be introduced to IoT design principles which cover how to transition from an IoT idea to an IoT product or solution, building prototypes and commercializing them. Since IoT is still emerging, businesses are going to be either adopting IoT solutions or transforming their existing businesses to include IoT in a seamless and sustainable manner. The course introduces students to business concepts that prepare participants to lead in this budding industry.

Prerequisite: EE222 Circuits and Electronics for Engineering students, CS323 Database Systems for CS/MIS students.

Objectives: After successful completion of this course, students will be able to: develop an end-to-end understanding of the emerging field of Internet of Things; to understand the connection between IoT data and the sensors and/or devices required to collect the data; to understand and explain the various reference architectures used in IoT and how they relate to the OSI reference model, identifying the various technologies and protocols at each layer; learn how to secure IoT systems; to appreciate the business perspectives of IoT and how to help a company adopt IoT in a profitable way; develop an IoT system consisting of hardware and software application, starting from the problem to the solution in an end-to-end fashion. This includes but not limited to: o selecting the technologies and protocols suitable to solving a particular IoT problem. o understanding and applying the steps required for IoT system design, taking care of the devices, network, application programming, data analytics and integrating all components into a functional; investigate emerging and specific aspects of IoT to gain insight, discover new technologies, etc.

Topic: Introduction to the Internet of Things; Smart Objects (Digital Senses – Sensors, Actuators and Devices); Connecting Smart Objects; Networking Overview; IP as the IoT Network Layer; Application Protocols for IoT; Data Analytics for IoT; IoT Platforms and Business Concepts; Security and Privacy for IoT; An Integrated IoT System Design and Development

Mode of delivery: In-person lecture, lab work

Textbooks:

- Hanes, D. et al. (2017). IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things. Cisco Press.
- Javed, A. (n.d.). Building Arduino Projects for the Internet of Things. Apress.
- Hossain, S. Z. (2018). The Definitive Guide: The Internet of Things for Business (3rd ed.). Aeris Communications.

- Sinclair, B. (2017). IoT Inc: How Your Company Can Use the Internet of Things to Win in the Outcome Economy. McGraw-Hill.
- Rossman, J. (2016). The Amazon Way on IoT. Clyde Hill Publishing.

CS452 Machine Learning

Description: Machine learning is the science of getting computers to act without being explicitly programmed. In the past decade, machine learning has given us self-driving cars, practical speech recognition, effective web search, and a vastly improved understanding of the human genome. Many researchers also think it is the best way to make progress towards human-level AI. This course provides an introduction to machine learning techniques. Students will learn how the techniques are applied, the mathematical and statistical unpinning of the models and how to explore proper application of the models. Topics include supervised and unsupervised machine learning, statistical inference and prediction. A wide variety of algorithms will be presented, including logistic regression, K-nearest neighbors, naïve bayes, decision trees, neural networks, k-means, mixtures of Gaussians, principal components analysis, expectation maximization. The course will also discuss modern applications of machine learning such as image segmentation and categorization, speech recognition, and text analysis. This course will briefly touch on societal and ethical effects of AI technologies. Students will explore the effects of these new technologies on culture.

Objective:

1. To understand and be able to explain the foundational principles underlying the field of machine learning.
2. To be able to implement algorithms for regression, classification, clustering, and neural networks.
3. To be able to design suitable machine learning models for ta given real-world problem.
4. To be able to read and understand machine learning research papers.
5. To be able to give presentation on machine learning work to technical and non-technical audiences.

Topics:

1. Regression/ Probability Theory
2. Linear Classifiers / Linear Regression
3. Maximum Likelihood and MAP Regression
4. Gaussian Dominant Analysis/ Naïve Bayes
5. k-Nearest Neighbors 6. Support Vector Machines
6. Regularization
7. Model Selection
8. Neural Networks (Representation, Learning)
9. Convolutional Neural Networks
10. k-Means Clustering
11. Mixture of Gaussians
12. Expectation Maximization
13. Principle Component Analysis
14. Dimensionality Reduction / Multidimensional Scaling
15. Anomaly Detection

Textbooks:

- Ian Goodfellow, Yoshua Bengio, & Aaron Courville (2016), Deep Learning, MIT Press. (Available on the Web)
- Christopher M. Bishop (2011), Pattern Recognition and Machine Learning, Springer.

Course title: CE 458 Internet of Things

Description: The Internet of Things (IoT) course takes an end-to-end view of IoT and tackles the devices, networks, data analytics, programming, security, and business aspects. This holistic approach exposes the student to all aspects of a functional IoT system and how to design robust, scalable and a secure IoT network. Labs and small projects will be used to gain understanding of key concepts at the various layers and drive a handson experience. Key among these are the devices, network protocols, database, and programming aspects. Students will review hardware types and software tools and be introduced to IoT design principles which cover how to transition from an IoT idea to an IoT product or solution, building prototypes and commercializing them. Since IoT is still emerging, businesses are going to be either adopting IoT solutions or transforming their existing businesses to include IoT in a seamless and sustainable manner. The course introduces students to business concepts that prepare participants to lead in this budding industry.

Prerequisite: EE222 Circuits and Electronics for Engineering students, CS323 Database Systems for CS/MIS students.

Objectives: After successful completion of this course, students will be able to: develop an end-to-end understanding of the emerging field of Internet of Things; to understand the connection between IoT data and the sensors and/or devices required to collect the data; to understand and explain the various reference architectures used in IoT and how they relate to the OSI reference model, identifying the various technologies and protocols at each layer; learn how to secure IoT systems; to appreciate the business perspectives of IoT and how to help a company adopt IoT in a profitable way; develop an IoT system consisting of hardware and software application, starting from the problem to the solution in an end-to-end fashion. This includes but not limited to: o selecting the technologies and protocols suitable to solving a particular IoT problem. o understanding and applying the steps required for IoT system design, taking care of the devices, network, application programming, data analytics and integrating all components into a functional; investigate emerging and specific aspects of IoT to gain insight, discover new technologies, etc.

Topic: Introduction to the Internet of Things; Smart Objects (Digital Senses – Sensors, Actuators and Devices); Connecting Smart Objects; Networking Overview; IP as the IoT Network Layer; Application Protocols for IoT; Data Analytics for IoT; IoT Platforms and Business Concepts; Security and Privacy for IoT; An Integrated IoT System Design and Development

Mode of delivery: In-person lecture, lab work

Textbooks:

- Hanes, D. et al. (2017). IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things. Cisco Press.
- Javed, A. (n.d.). Building Arduino Projects for the Internet of Things. Apress.
- Hossain, S. Z. (2018). The Definitive Guide: The Internet of Things for Business (3rd ed.). Aeris Communications.
- Sinclair, B. (2017). IoT Inc: How Your Company Can Use the Internet of Things to Win in the Outcome Economy. McGraw-Hill.
- Rossman, J. (2016). The Amazon Way on IoT. Clyde Hill Publishing.

EE 421 Digital and Analog Signal Processing in Telecommunications
Elective for CE and EE students
Prerequisite: Communication Systems
Credit Hours: 4; Ashesi Credit Units: 1; Hours per week classroom: 3; Hours per week discussion/lab: 3

This course includes the study of signal processing and technology used in the telecommunication industry. Students will study various digital and analog signal processing techniques. Starting from the basic definitions of a discrete-time signal, through Fourier analysis, filter design, sampling, interpolation and

quantization, more advanced tools are studied to aid the study and design of digital communications systems. Note: CE and EE students wishing to work in the telecommunications industry are advised to take *Digital and Analog Signal Processing in Telecommunications* as one of their electives.

Topics: Discrete time signals and systems; transform analysis of linear time invariant systems, z-transforms, sampling of continuous-time signals, structures for discrete-time systems, Fourier transforms, fast Fourier transforms, computation of the discrete Fourier transform, Fourier analysis of signals using the discrete Fourier transform, signal averaging, signal compression, convolution, parametric signal modeling, discrete Hilbert transforms filters, complex techniques, and applications of all of these.

Lab Exercise: Signal processing, spectrum analysis.

Textbook: Oppenheim, A. V., & Schafer, R. W. (2010). Discrete-Time Signal Processing (3rd ed.). Pearson..

***References*:**

- Lyons, R. G. (2010). Understanding Digital Signal Processing (3rd ed.). Prentice Hall.
- Smith, S. (2002). Digital Signal Processing: A Practical Guide for Engineers and Scientists (3rd ed.). Newnes.
- Prandoni, P., & Vetterli, M. (2008). Signal Processing for Communications. EPFL Press.
- Ifeachor, E.C., & Jervis, B.W. (2001). Digital Signal Processing: A Practical Approach (2nd ed.). Prentice Hall.

Course title: CS 455 Applied Cryptography and Computer Security

Description: Computer Security concerns the theory, concepts, techniques and tools used to ensure confidentiality, integrity, and availability. This means understanding security frameworks, threat models, security policies, and mechanisms for prevention, detection, and recovery from attacks.

Prerequisite: Data Structures or Discrete Math, Database management Systems, Computer Programing for Eng.

Objectives: To provide students with the skills and techniques to understand computer systems from a security perspective, develop understanding of security threats and how to deal with them, appreciate some of the best practices, and capable of securing different aspects of computer systems. Though there is no such thing as perfect security, we show student as much as possible so they stand a good chance of overcoming adversaries.

Topics: The course is structured with 8 different modules.

- CIA and Threat Model such as DREAD and PASTA
- Software Security including buffer, format string and integer overflows
- Social Engineering, including phishing, pretexting and vishing
- Historical Cryptography, including mono and polyalphabetic ciphers
- Symmetric key cryptography, including DES and AES
- Public key cryptography, such as Diffie-Hellman and RSA
- Authentication, access control, and integrity including certificate authorities, MACs, and cryptographic hash functions
- Web security topics such as cross-site scripting, cross-site request forgeries and SQL injection

Mode of delivery: In-person lecture, lab work

Textbooks:

- Menezes, Oorschot, and Vanstone, Handbook of Applied cryptography, CRC press (Free, legal PDF)
- Ross Anderson, Security Engineering, 2nd Edition, Wiley (Free, legal PDF)
- Various web resources and readings and research papers examples include

- S Samonas, D. Coss, "The CIA Strikes Back: Redefining Confidentiality, Integrity And Availability In Security", Journal of Information Security, Vol 10, No. 3
- Aleph One, "Smashing The Stack For Fun And Profit", BugTrack and Underground.org Phrack 49 Vol 7, No 49
- R Peeters et al, "n-Auth: Mobile Authentication Done Right", In proc of ACSAC 2017, December 4–8, 2017, San Juan, PR, USA
- A Threat-Based Cybersecurity Risk Assessment Approach
- Investigating Potential Barriers to Cybersecurity Risk Management Investment in SMEs

Course title: CE 452 Very Large-Scale Integration (VLSI)

Description:

This class will be using a variety of tools that will give students experience with full-custom and automated CMOS semiconductor design.

As part of this class, we will be designing chips for OpenRoad (full custom) / OpenLane (synthesized) chips and possibly fabricating chips with eFabless. To accomplish this, we will be using several open-source tools.

Prerequisite: Digital Systems Design

Objectives:
After completing the course, the student will be able to:

1. Design a chip with a top-down design approach with bottom-up implementations.
2. Assess tradeoffs in CMOS circuit designs that contain opposing constraints.
3. Optimize CMOS circuit designs for given criteria.
4. Design tests and run simulations to verify CMOS circuit designs.
5. Explain common steps used by integrated circuit (IC) CAD software.
6. Understand what the career of an IC designer entails.
7. Build digital circuits using hand layout.
8. Build digital circuits using standard cells.
9. Implement testable CMOS circuit circuits.
10. Calculate parasitic capacitances, and resistances of CMOS circuits.
11. Use algorithms to find minimized digital circuits.
12. Describe procedures for routing and placement of standard cells.
13. Demonstrate the ability to use modern VLSI CAD tools, such as Magic, Yosys, Netgen, Cocotb
14. Demonstrate the ability to use modern software tools such as Github, VirtualBox, Docker
15. Demonstrate the ability to work in teams, including problem decomposition and solution integration

Topics: VHDL review, transistors, non ideal transistors. Spice melting and function simulation. DC transients, Power, Logical Effort, EFabless, Circuit layout. Combinational and sequential logic. Circuit families, Tests, wires, scaling, pitfalls, adders, datavpath, MIPS

Textbooks

- “CMOS VLSI Design: A Circuits and Systems Perspective, 4th edition” By Neil H. E. Weste and David Money Harris.

Course title: CE 432 – Neural Networks

Description: Artificial neural network (ANN) is a numerical implementation of the processing functionality of the human brains to solve real world or physical problems. The concept is based on the notion of massive parallel and distributed computing with learning approach of the brain. Neural networks are able

to self-generate when given an objective, training data, and computing power. Typical of an intelligent system, neural networks possess abilities such as being able to acquire information by themselves, have a structure that is flexible enough to represent the information, and have mechanisms that enable them to adapt to their environment using the information acquired. By virtue of its capabilities and versatility, neural networks hold significant promise on how complex engineering and scientific problems could be solved. Neural networks techniques have brought major innovations in applications such as driverless cars, robotics, face recognition, speech and pattern recognition, prediction systems, industrial automation, smart manufacturing, autonomous vehicles, aerospace, financial systems, banking system, defense, entertainment, telecommunications, transportation, agriculture, social media, medical diagnosis, etc. This course will provide the fundamental concepts on operations of neural networks, architectures and design, learning rules and training of the neural network for applications. Emphasis will be placed on the design principles, mathematical analysis of the networks, methods of training, and their application to solve engineering problems. Matlab tool will be used to design and test various network architectures. As part of the course students will undertake a special course project that will involve developing a neural network model to solve a practical engineering problem.

Objectives: The goal of neural networks is to realize an artificial intelligent system that functions along the human brain model. In this regard, the course will introduce students to the concepts required to design desired neural network architecture for applications, how to train the neural network to function, and how to use the neural network to acquire knowledge from environment. Also, to provide further knowledge required in understanding courses in artificial intelligence, machine learning, and other intelligent techniques for solving problems of pattern recognition, function approximation, control systems, and data analytics.

A student who completes the course successfully will be able to:

1. Understand the neurological context of neural networks.
2. Have a good understanding of the computational theory underlying neural networks.
3. Know nonlinear patterns and how they are recognized by networks.
4. Have good knowledge of neural network architectures, how the networks are designed, implemented, and trained to learn patterns, and the learning rules or algorithms required to train the network for solutions.
5. Know the difference between supervised and unsupervised networks, their architecture, learning techniques, and their development for applications.
6. Know how to use neural network to solve different problems.
7. Have experience on neural network model development and programming to perform computational tasks.

Textbooks

- Charu C. Aggarwal, (2023), “Neural Networks and Deep Learning: A Textbook”, Springer
- Martin T. Hagan, Howard B. Demuth, Mark H. Beale, and Orlando De Jesus, (2014), “Neural networks design”, 2nd Ed., Martin Hagan
- Simon Haykin (2009) “Neural networks and learning machines”, Prentice Hall
- Laurene Fausett (1994), “Fundamentals of neural networks: Architecture, algorithms, and applications”, Prentice Hall
- R. Callan (1999), “The essence of neural networks”, Prentice Hall, 1999.
- Bishop, C. M.,)1995) “Neural networks for pattern recognition”, Oxford Press, 1995.

Reference textbooks focusing on practical aspects of the course.

- Timothy Masters (1995), “Practical neural networks recipes in C++”, 1st Ed., Wiley.
- Russell Reeds, and Robert J. Marks II, (1999) “Neural smithing: Supervised learning in feedforward artificial neural network”, Bradford Books, 1999.

CS313: Intermediate Computer Programming

Course Description:

This course is a continuation of Object-Oriented Programming (OOP) with Java. It will introduce students to the C++ programming language and teach them to implement in C++ the OOP concepts and ideas they have previously learned. It will introduce additional concepts that will enable students develop moderately sized applications. These additional concepts will include event-driven programming, multi-threading, design patterns and Unified Modeling Language (UML). The unique advantages of C++ will also be emphasized such as those they bring to Operating Systems and Big Data.

Course Objectives:

After successful completion of this course, students will be able to:

1. Make use of software engineering to develop moderately sized applications.
2. Make sound judgements as to Object Oriented Design and efficient data structures.
3. Design, develop and document applications for business applications.
4. Develop procedural and OOP applications in C++.

Topics:

- Design Patterns and Software engineering practices
- Coding conventions
- Basic IO and control structures
- Function overloading
- Pointers and dynamic arrays
- Structures and classes
- Inheritance
- Operator overloading
- File I/O

Labs: Lab session consist of individual programs written in lab, as well as a few group projects. Labs cover all topics discussed and progressively integrate knowledge acquired. Two major projects are also included.

Reading materials:

Primary Textbooks:

- Amanquah, N., Intermediate Computer Programming in Java and C++ (unpublished book draft).
- Savitch, W. (2016), Absolute C++, 7th Ed., Pearson Education Ltd.

Additional References:

- Schildt, H. (2002), C++ The Complete Reference, 4th Ed., McGraw Hill
- Deitel P., Deitel H. (2017), C++ How to Program, 10th Ed., Pearson

Related Online Course:

- C++ documentation (www.cplusplus.com)

Course title: CS441: Mobile Application Development

Course Description: This course introduces the principles of developing interactive mobile applications and services that may be resident on a phone or the web. There will generally be interaction between the client app and the service online.

Students will be exposed to a variety of different popular, contemporary or emerging platforms and operating systems, and be sufficiently informed about the different options and capabilities available on these platforms. Students will also be exposed to the features (both hardware and software) and sensors available on mobile devices and will be encouraged to explore their use in building applications and services.

This course requires good programming skills in at least a working knowledge of one language, as well as web development ability. Principal topics include mobile friendly mobile web application development. Client-side application development on platforms which include at the minimum Android will be explored. Contemporary cross platform approaches will also be investigated.

Insight into entrepreneurship (building a business around a mobile application) will be provided. Attention will be paid to emerging technologies. The course is very project oriented, as students must receive many hours of hands-on practice and experimentation.

Objectives:

1. To equip students with the skills to design mobile phone applications – for smart phones and everything in between.
2. To empower students to design and develop and deploy their own web services that are mobile friendly.
3. To encourage students to become mobile app entrepreneurs.
4. To identify needs and opportunities in the developing world and to develop businesses and services out of these.

Topics:

- Galaxy of Mobile, purpose, choices, structure & prerequisites
- Idea to prototype
- Native: Android and iOS
- Hybrid
- Cross platform
- Comparison and choice
- Hybrid development: ionic framework
- Security & Privacy
- Hybrid development: local resources, page life cycle,
- Native development - android

Reading Materials:

Primary Textbook:

- Marco Tabor & Mladenka Vrdoljak (2017), Mobile Developer's Guide to the Galaxy. Creative commons

Additional References:

Android:

- Wei-Meng Lee (2011), Beginning Android Application Development.
- Mark L Murphy (2008), The busy coders guide to Android Development
- Reito Meier (2014), Professional Android Development.
- Zigurd Mednieks et al (2012), Programing Android.

Windows Mobile

- Nathan Adam (2012), Windows 8 Apps with XAML and C#.
- Falafel Software (2013), Pro Windows Phone App Development.
- B. Tabor, C. Rutkas, L. Lieberman (2014), Windows Phone 8 development for absolute beginners

- Microsoft Open Technologies Inc (2016), Windows Phone 8 Guide for Android Application Developers.
- Almog, C. Fishbein, E. Coolman (2017), CodeName One Developer guide.

Mobile Web & Cross platform:

- Maxmiliano Firtman (2012), JQuery Mobile Up and Running, O'Reilly.
- Maxmiliano Firtman (2010), Programming the Mobile Web O'Reilly.
- Matt Neuberg (2013), Programming iOS, O'Reilly.

Additional Up-to-date Resources –to be provided on a per topic basis.

CS461 DATA SCIENCE

Course Description: Data Science is a powerful toolkit for using data to answer questions and guide decision making. It involves skills and knowledge from statistics, software engineering, machine learning, and data engineering. This course is designed for students interested in using a powerful data science toolkit to collect, clean, pre-process, visualize datasets and fit models. It will provide most of the knowledge needed to start applying statistical and machine learning algorithms to projects by combining hands-on practice with the essential theory. In this class, students work on data science projects that involve collecting data or finding data sources, exploratory data analysis and interactive visualization, statistical analysis, predictive analytics, model selection and validation. Course work also involves readings and case studies on ethical practice in data science.

Objectives:

1. As an outcome of this course, students will be able to:
2. Collect data from different data sources, clean data and construct data visualization.
3. Calculate and interpret basic descriptive statistics.
4. Describe and use properties of basic probability distributions.
5. Understand and be able to perform statistical inference in the form of confidence intervals and hypothesis tests.
6. Build different regression models like simple regression, multiple Regression, polynomial regression, ridge regression, the Lasso, and logistic regression.
7. Perform linear models' selection.
8. Use dimension reduction methods.
9. Fit a tree-based models like regression trees, classification trees, bagging, random forests, and boosting
10. Divide a dataset into training and test datasets to train and evaluate the performance of different models
11. Understand clustering methods like K-Means and Hierarchical clustering.
12. Match a statistical and machine learning algorithm to a given dataset.
13. Communicate a data story both verbally and in written form.

Topics:

- Data and Statistical Thinking,
- Quantitative and Qualitative data,
- Methods for describing sets of data using graphs and numbers,
- Probability Distributions and Sampling Distributions,
- Inferential Statistics: Estimation with Confidence Intervals; Test of Hypothesis,
- Supervised learning methods: regression and classification problems,
- Unsupervised learning methods: clustering algorithms.

Textbooks:

- Douglas Shafer and Zhiyi Zhang (2012), Introductory Statistics. Available at https://open.umn.edu/opentextbooks/textbooks/135
- Gareth James, Daniela Witten, Trevor Hastie & Robert Tibshirani (2013), An Introduction to Statistical Learning. Available at https://statlearning.com/
- Required Software:
- R and RStudio. R statistical programming is an open-source software and is the primary software used in the course.

Humanities and Social Sciences and Liberal Arts Core

AS 111 Ashesi Success
Required for All Freshmen
Prerequisite(s): None
Typically offered in Semester Two
Course Type: Seminar, Experiential
Credit Hours: 3; Ashesi Credit Units: 0; Hours per week classroom: 3; Hours per week discussion: 0

A program designed to enhance your overall success in college and in life. The most important objective of the program is personal empowerment: learning who you are as a college student, learning who you are as a human being and what you stand for, learning how to speak up when your values are in conflict with those around you, and learning what it takes for you to keep yourself balanced and on course to success. When you are empowered, your actions are more purposeful and your choices more deliberate. When you are empowered, you are more engaged and more motivated every day. And when you are empowered, you have a greater sense of well-being and enjoyment in life.

Core Course Electives

First Year Experience Courses

ENGL 001 Writing, Public Speaking, and Multimedia Communications
Required for All Freshman
Prerequisite(s): None
Typically offered in Semester One
Course Type: Lecture
Credit Hours: 4; Ashesi Credit Units: 1; Hours per week classroom: 3; Hours per week discussion: 1

This course is designed to equip you with effective communication, research, and analysis skills that will enable you to successfully present your team's work for the Challenge and prepare you for further development of these skills in the Written and Oral Communications course in Spring. You will specifically hone your skills in the following areas: writing, public speaking, argumentation, multimedia communication, and research. You will also build your teamwork skills by collaborating on the culminating project together, which will be in-class team debates on contemporary issues related to the African Development goals 3, 7, and 18 (healthy and nourished citizens, environmental sustainability, and youth empowerment).

FYE 001 How to Communicate Like a Leader (Optional)
Required for All Freshman
Prerequisite(s): None
Typically offered in Semester One
Course Type: Lecture
Credit Hours: 4; Ashesi Credit Units: 1; Hours per week classroom: 3; Hours per week discussion: 1

In this intensive, two-week course experience, students model leadership scenarios by learning the elements of oral communication by leaders, analyzing real-world examples, and finally role-playing competing interests while collaborating on an original speech. This course builds on skills learned in Written, Oral, and Multimedia Communication class in Ashesi's the first-year experience in Semester 1 of the academic year 2020-2021 by reflecting on the motivations and tradeoffs involved in pleasing different constituencies of the audience for a speech. Structured discussion and reflection enables students to gain a deeper understanding of the opportunities and challenges inherent in winning support while remaining ethical.

FYE 002 English Bridge (Optional)
Required for All Freshman
Prerequisite(s): None
Typically offered in Semester One
Course Type: Lecture
Credit Hours: 4; Ashesi Credit Units: 1; Hours per week classroom: 3; Hours per week discussion: 1

Students will hone their reading writing skills through intensive workshops focused on developing their reading comprehension and writing clarity and concision. This optional module is for students who qualified for this module based on the first week diagnostic assessment and for any other students who would like to join the course.

ENGL 112 Written and Oral Communication
Required for all BA, MIS & CS, ENG Majors
Prerequisite(s): None
Typically offered in Semester Two
Course Type: Lecture
Credit Hours: 4; Ashesi Units: 1; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This course seeks to guide students to discover or re-discover their identity (or identities) as formal writers and speakers. To this end, this course will endeavor to introduce and have students critically assess established identities in text construction (writing and speaking) as well as consumption (reading and listening). Besides multiple opportunities to speak and write logically and with originality, students have the opportunity to practice, think and talk about the writing process and experience. You will learn to plan, organize, revise and edit your writing. You will also learn to apply the techniques of critical reading and personal reflections to understand and think about your writing process. The course also emphasizes peer review and reflective writing as important strategies for conversing about writing. In this class, we will engage writing and communication as a socially situated act that is significantly shaped by experience and context.

ENGL 113 Text and Meaning
Required for all MIS & CS, ENG Majors
Prerequisite(s): Written & Oral Communication
Typically offered in Semester One
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Text and Meaning is one of the foundational courses at Ashesi University. This course invites students to turn their critical and creative attention to the study of literary and critical theories such as Feminism, Marxism, and Postmodernism among others. Through readings and activities that welcome critical thinking, students will participate in a range of activities that will enhance their ability to pose questions, propose hypotheses, gather and analyze data, and make arguments. Within this course, the term 'text' is used in its broadest possible sense, and includes literature, newspapers, magazines, speeches, advertising, websites, blogs, film, music and documentaries. Likewise, reading is theorised and given an expansive scope that covers not only the processing of letters on a page but text consumption more broadly, including listening, viewing/watching, observing, and other modes. As in Written and Oral Communication, students will share their research and findings through a range of written and multimodal assignments.

SOAN 325 Research Methods
Required for all BA, MIS & CS Majors
Prerequisite: Statistics, or Statistics for Engineering & Economics
Typically offered in Semester One
Course Type: Lecture
Credit Hours: 4; Ashesi Credit Units: 1; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The course is designed to provide the student with broad fundamentals of research methods. To this end, students will be introduced to quantitative, qualitative and mixed methods approaches for conducting research. Students will be guided through the various stages of conducting research; i.e. writing research proposals, where they will identify problems to study; collecting information by conducting appropriate literature review; collecting appropriate primary and/or secondary data; analyzing data; writing mini reports; and critiquing published articles. Class time will be devoted to lectures, data analysis and in-class assignments. The course is hands-on, using R as the main software.

Leadership Seminar Series

The Leadership Seminar Series is a series of interdisciplinary seminars designed to promote self-awareness among Ashesi's students and to expose them to the ideas of great historical thinkers and contemporary leaders. Students will be asked to think broadly and to explore how they might use the examples set by other leaders to achieve their goals in their future professional lives. The leadership seminar series draws upon experts in different fields of corporate, social and academic life. Students must complete the full series in order to graduate from Ashesi University. The series consists of the following seminars:

SOAN 111 Leadership Seminar 1
Required for all BA, MIS & CS, ENG Majors
Prerequisite(s): Ashesi Success; Written and Oral Communication
Typically offered in Semester One
Course Type: Seminar
Ashesi Units: 0.5; Credit Hours: 2; Hours per week classroom: 1.5; Hours per week discussion: 0
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 3 per week)

This course explores such questions as “What is good leadership? “What are the attributes of a Great Leader? and “What does a good leader do or not do? In this seminar, students will do readings of various historical and contemporary public and business leaders and explore the ethical dimensions of leadership. This is a half unit seminar taught in the format of discussions and assigned readings.

Course content addresses the purpose of leadership and the qualities of a great leader. Students will explore ethics and civic engagement in course readings and discussions. By comparing frameworks for leadership and ethical decision-making and applying those frameworks to leaders in a variety of contexts, students learn to analyze and evaluate the leadership they observe around them. Weekly writing assignments build students’ skills in reflective writing. In-class discussions and debate build students verbal communication and presentation skills.

SOAN 211 Leadership Seminar 2
Required for all BA, MIS & CS, ENG Majors
Prerequisite(s): Leadership Seminar 1
Typically offered in Semester Two

Course Type: Seminar
Ashesi Units: 0.5; Credit Hours: 2; Hours per week classroom: 1.5; Hours per week discussion: 0
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 3 per week)

This seminar probes the most fundamental questions about the good society: "What are the most fundamental rights of humanity? "What impact does national government have on the trajectory of nations? "What is the Social Contract - Rule of Law, and what impact does it have on civilizations?

After taking this seminar, students should have a deeper understanding of constitutional law and the concept of nations, whose leaders are expected to be servants of the people. This seminar also expands on the discussion of ethics, from corporate social responsibility to ethical issues in public office. Students will develop their skills in writing analytical and reflective papers.

SOAN 311 Leadership Seminar 3
Required for all BA, MIS & CS, ENG Majors
Prerequisite(s): Leadership Seminar 2
Typically offered in Semester One
Course Type: Seminar
Ashesi Units: 0.5; Credit Hours: 2; Hours per week classroom: 1.5; Hours per week discussion: 0
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 3 per week)

Leadership III seeks to challenge reflective thinking on what constitutes a "good society" and how best economic activity could be organized to realize it. How do we best achieve a balance of liberty, efficiency, equality, and community? At the end of this seminar series, students should have a better understanding of the interplay between natural and civic rights on the one hand and sustainable economic activity on the other. The aim is not to achieve consensus among participants as much as to get students to appreciate the tensions among various elements of the good society and why even within a predominantly capitalist democratic society, people may disagree and pursue differing philosophies.

The Leadership III module builds on the foundations of Leadership I and II by focusing on the issues pertaining to the economic organisation of the good society from the perspective of leadership as an inclusive, participatory, and ethical process of change-making in society.

This course provides students with an opportunity to engage and explore classic texts in economics, political economy, and development to understand and familiarize themselves with the various theoretical and philosophical arguments and concepts in the field of development and leadership while forming their own views and positions on economic matters. Moreover, the course allows the students to apply the philosophical arguments of selected texts to explore current global Sustainable Development Goals (SDGs) by using current data and resources to analyse socio-economic issues in the world with special reference to African nations.

SOAN 411 Leadership Seminar 4
Required for all BA, MIS & CS, ENG Majors
Prerequisite(s): Leadership Seminar III
Typically offered in Semester One and Semester Two
Course Type: Seminar
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This course is a capstone to the Leadership Seminar Series and puts into practice many of the general concepts discussed in the previous leadership seminars and other courses taken at Ashesi. Service-

learning, a vital component of the course, is intended to help you develop a sense of citizenship by becoming engaged with your surrounding community, putting the lessons learned throughout your leadership journey in the various seminars into practical use.

Servant leadership is the core concept we will explore in this seminar. You will have opportunities to reflect on the concept in different ways, including assigned readings and class discussions, debates, identifying and finding solutions to a service project in a community of your choice, various reflective assignments, team, and individual presentations, flip classrooms, shared readings, journaling, and guest speakers. This seminar is a full-unit capstone, it is not meant to be a 'cerebral' course. It's supposed to tug at your heart primarily; therefore, reading ahead of class is crucial. You will be expected to:

1. Respect our **Circle of Trust**, as we share both shallow and deeply personal experiences and thoughts. NOTHING is a taboo topic in this class. If it's on your mind, let's share it!
2. **Open up and participate fully** in all discussions so we can learn from you. No silent spectators!
3. **Be willing to serve and serve well**! Quantum leaders inspire & institutionalize positive change!

The overarching purpose of this seminar fits squarely within Ashesi's mission with its focus on ethical leadership. If the next generation of leaders embraces service as central to leadership, we can help transform our continent and the world! The course content will challenge you to reflect deeply on your leadership journey through the lenses of multiple Servant leadership concepts, including self-awareness, personality, and communication and public speaking for impact, leading quietly, followership, power versus service models of leadership, managing and learning from failure, Ubuntu, key practices of Servant leaders, through the examples of Servant leaders and changemakers across the African continent and in-class guests culminating into a practical opportunity to act out your sense of citizenship through your service project. Finally, the seminar aims to equip you with the needed skills to identify, analyze and evaluate the actions and activities of Servant leaders around you with a particular focus on civil society, advocacy and activism, private and public sectors, NGOs, and social entrepreneurship.

Africana/African Studies Elective Courses

ENGL 231 African Literature & Film
Non-major elective
Prerequisite(s): Written & Oral Communication, Text & Meaning
Typically offered in Semester One & Two
Course Type: Lecture
Credit Hours: 4; Ashesi Credit Units: 1; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This course aims to introduce students to some of the major debates in the subjects of African Literature and Film. Through an interdisciplinary approach, we will study African cultural creations in both mediums and others subtending or related to them, supplemented with short theoretical readings centered on the following interconnected topics: decolonization, gender, language and storytelling.

We will cover a range of themes, issues and debates, including but not limited to the following: the continent's engagement with Western thought and literary traditions, explore traditional oral literatures, examine commonalities in style and theme and tackle issues of gender and ethnicity. We will also examine literary works as complex expressions of their contexts, as well as indicators or an index of the values and worldviews of the societies in which they were composed from which they emerged, and those they came to subsequently enter.

The class is delivered through a variety of means, employing various techniques. Through class discussions, writing assignments and individual research, students will be able to combine, integrate and ultimately contribute to the sum of knowledge learned in this class with knowledge and skills gained in other courses, notably Written & Oral Communication and Text & Meaning.

POLS 221 African Philosophical Thought
Non-major elective
Prerequisite(s): Written & Oral Communication, Text & Meaning
Typically offered in Semester One
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

A serious thinking through or reflection on the practical/tangible aspects of the human experience is the goal of philosophy. This course is an introduction to a variety of themes of philosophical thinking in Africa. The approach adopted to advance the goals of the course, differs from traditional philosophy courses in a significant way. Specifically, we will read about the works of African philosophers; apply/interrogate such thoughts in such works to grounded cultural practices in actual and mediated lives; and think through and dialogue with fellow colleagues on the readings in this class. Thus, needless to say, throughout the course we will use concrete examples to ground readings which may sometimes be abstract. The goal of this grounded approach is to demonstrate the relevance of philosophical thinking in contemporary times and also to negate the idea that 'philosophy' does not 'touch ground' (that is, it is only intellectual exercise) and is thus only a 'thinking' (and boring) subject.

POLS 231 Africa in International Settings: Africa Beyond Aid
Non-major elective
Prerequisite(s): Written & Oral Communication, Text & Meaning
Typically offered in alternate years
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Across the African continent many want to do away with decades of aid dependency striving instead for a more assertive Africa on the international scene. This course encourages informed debate and a varied assessment of what overseas development assistance has evolved into over the years and how can it be complemented and replaced by more effective and relevant resources. It will offer a variety of case studies from individual African countries as well as identifying regional trends and characteristics.

The course aims to locate the topical 'Beyond Aid' debate in a theoretical, historical and regional perspective. It offers an introduction to main tenets of development theory and provides an overview of how international norms guiding development policy have evolved from the first development decade of the 1960s to the Sustainable Development Goals (SDGs) adopted by the UN in 2015.

Furthermore, the course assesses the changing role of development assistance in the context of African economic and social development and will compare contemporary data on the role of aid relative to trade, remittances and foreign direct investments. It will look at challenges confronting African countries aiming to offer a more diverse and varied understanding of development options and constraints relative to the often-stereotyped perceptions of 'one size fits all' presumably meant to apply across 54 very different

nations on the continent. And it will look at how access to financial resources influence the position of African governments in shaping current geopolitical alliances.

POLS 332 Governance in Africa
Non-major elective
Prerequisite(s): Written & Oral Communication, Text & Meaning
Typically offered in Semester Two
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Scope & Sequence
'Governance in Africa' forms part of the African Studies Elective course for level 300 designed for students pursuing 3rd and 4th years. The course helps students prepare for capstone projects and may further provide useful context for other courses taught in social theory, leadership 3 and 4, international trade & policy. During the course, students will be assisted to understand basic research methods, familiarize with the American Psychological Association (APA) formatting and referencing requirements, use of library and web resources to acquire relevant data and literature, and apply analytical skills and critical thinking to class debates as well as the submission of summative assessment papers.

Research Base

Ordinarily, the concept of 'governance' mirrors activities being undertaking by government(s). In international diplomacy, public policy and social theory, the concept is usually associated with prefixes such as good or bad governance, responsible or accountable governance, effective or ineffective governance, amongst others.

Since the 1990s, international development partners have addressed, and continue to engage in diverse development challenges in response to the changing global dynamics. In the Sub-Saharan Africa, where under development continue to linger, 'good governance' has found space in governance lexicology and considerably shaped policy direction as well as formed part of precondition(s) for development assistance.

Primarily, stakeholders' efforts have focused on the supply side of governance: enhancing capacity of state institutions to public participation, coordination, engagement, accountability, equity, transparency and other well-intentioned considerations. Later developments witnessed a shift of attention to the demand side where civil society and non-state players articulate interests and demand access to government. Subsequently, academic literature has focused on the interface of both the demand and supply side of governance.

Accordingly, 'Governance in Africa' seeks to unveil governance beyond the prerogative of government. The course presents an institutional process involving multiple actors in and outside the confines of government striving at authoritative decision-making arrangements. Governance is presented recognizing the geographical and social contexts, thus, projecting a 'best-fit' practical approach as opposed to the superlative conception of 'best practice'.

The course offers students analytical track to understanding existing governance arrangements in Africa, considers available opportunities and institutional arrangements and how these can be fine-tuned to ensure more responsiveness to the needs of society – public and private interests.

SOAN 225 Ghanaian Popular Culture
Non-major elective

Prerequisite(s): Written & Oral Communication, Text & Meaning
Typically offered in Semester Two
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This Ghanaian Popular Culture course is an undergraduate, 300-level, African Studies elective at Ashesi University. The course uses creative and engaging content in Ghanaian Popular Culture (for instance, video movies, vehicle inscriptions, political cartoons) as a channel for teaching disciplinary analytical thinking and reasoning skills to focus on academic writing, and to indirectly prepare students for capstone projects.

SOAN 233 African Music and the Contemporary Art Music Scene
Non-major elective
Prerequisite(s): Written & Oral Communication, Text & Meaning
Typically offered in Semester Two
Course Type: Lecture, Experiential
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This course explores how the character of traditional African traditional music and culture has been reimagined and integrated in contemporary times as Popular, World, Jazz, and Afro Beat and Art/classical music forms by nationalistic African composers. We analyze these music genres for African 'signifiers', consider selected scholarly theories about Afro-classical music by Akin Euba, John Nketia, and Kofi Agawu, formulate theories, applications, and conclusions about the marketing and reception Afro-classical music, and reflect on our own social responsibility to this music genre as educated Africans.

The course content is found in Canvas. Reading articles are stored in Canvas in their pdf formats. The lecture itself is on zoom and accompanied by Google slides. All relevant data can be found on the slide which can be accessed through a link. A significant portion of the lecture is spent listening to music and discussing the compositions. Music links are found on the weekly google slides. Weekly announcements as well as a calendar are presented on Canvas and updated by the Faculty Intern to keep students apprised about weekly expectations. In addition to (2) two weekly lectures, there is an hour-long discussion class held by the FI.

Mission: The mission of Ashesi University is to educate a new generation of ethical, entrepreneurial leaders in Africa; to cultivate within our students the critical thinking skills, the concern for others and the courage it will take to transform a continent.

Vision: Our vision is an African renaissance driven by a new generation of ethical, entrepreneurial leaders. We aim to educate such leaders, and to drive a movement in African higher education to scale up the education of such leaders.

SOAN 322: African Cultural Institutions
Non-major elective
Prerequisite(s): Written & Oral Communication, Text & Meaning
Typically offered in Semester Two
Course Type: Lecture
Credit Hours: 4; Ashesi Credit Units: 1; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Contemporary African societies reflect the interplay of tradition and change. The institutions of the past have not simply given way to the newer ones of the present. It is an interplay among what Ali A. Mazrui called a "Triple Heritage" of Indigenous Africa, Islamic Africa, and Euro-Christian/Western Africa. Kwame Nkrumah identified the same dynamic and described it as "Consciencism"—how these three influences on contemporary African life and institutions generate a "crisis of conscience". Thus, African cultural institutions and practices continue to give direction to the internal and external changes that are taking place in Africa and in the Americas today. This course examines the social, political, economic and religious institutions embodying patterns of culture that have evolved over thousands of years and represent Africa's contribution to global civilization. The course enables students to see Africa in a global perspective and provides a framework for scholarly reflection. We approach this course from socio-anthropological perspectives and identify culture as:

- A lived experience developed over time with contours and detours based on geography, history and environment,
- African cultures as different yet similar to all other cultures

The course focuses on three interrelated themes: (a) Cultural processes and institutions that existed just prior to the "arrival" of Europeans, (b) the raptures to these cultural processes and institutions—caused especially by the trans-Atlantic slave trade and its subsequent colonial phase, and (c) the legacies of these ruptures during the postcolonial era to the present. Of particular concern will be the effect on processes of development and democratization. The integration and/or influences of African cultural institutions with other parts of the world, and the centrality of "Africa" in the world receive attention.

SOAN 227 Religion in Africa
Non-major elective
Prerequisite(s): Written & Oral Communication, Text & Meaning
Typically offered in Semester Two
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This course is an introduction to a cross-cultural study of religions and cultures of Africa through the disciplines of anthropology, history, and sociology of religion. The goal of the course is to teach students to think critically about the traditional religious heritage of Africa as a profound reflection on the human condition. This goal is achieved through a systematic study of the attitudes of mind, beliefs, as well as practices which have evolved in the many African societies such as the Akan of Ghana, Yoruba and Ibo of Nigeria, Malinke of Guinea, the Ewe/Fon of Dahomey/Benin, the Luo of Tanzania, K(G)ikuyu and Masai of Kenya, the Zulu of Southern Africa, and the Mende of Sierra Leone. Through the viewing of documentary films, movies, lectures, and discussions, the meaning, structure, nature, and world views of contemporary Africans are closely examined.

In addition, the course offers an overview of how cultural and religious knowledge is generated, understood, and used as Africans in general and Sub-Saharan Africans in particular, draw on their music and dance, myths, art forms and symbols to articulate and elaborate on the cosmos, life, sickness, health, and death, as they organize their lives. It does so by retrieving and analyzing the significance of creation myths, religious personalities such as rulers, diviners, and healers, in relation to the role of the ancestors.

Finally, it reflects on the social, cultural and historical factors which have engendered religious changes in Africa. Particularly it unpacks the problematic emergence of two world religions, Christianity and Islam—"Guest Religions"—and their encounters with the indigenous religions of Africa. Attention is paid to the

impact is the "host" on the "guest" religions. In the end, it is hoped that students are enabled to interpret, articulate and synthesize religious knowledge, experience, and reflection as they deal with African ideas, belief systems and practices.

SOAN 301 Introduction to Africana Studies: The Global Black Experience
Non-major elective
Prerequisite(s): Written & Oral Communication, Text & Meaning
Typically offered in Semester One and Semester Two
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

Introduction to Africana Studies surveys the sum-total of the content of Black peoples' lives historically and in the present. The course raises and attempts to answer some key questions: What is the nature and historical contours of the Global Black Experience? How have our understandings and appreciations of this experience changed over time? What is "Africa" to (a) Continental Africans? (b) Caribbean/South American Africans? (c) North American Africans and (d) Indian (Asia) Africans—such as the Sidi of Mumbai? The term "Africana" therefore encapsulates the "wide community" of Africa. It offers an openly conceptual framework to attract new and emerging ways of understanding the global Black experience.

The course therefore explores the interconnectedness of Black subject identities, experiences, issues, themes, as well as topics, and applies them dynamically to diverse locations of the Black world. Specifically, it sheds light on the global approach to the African Diaspora, showing how globalism underscores the distinctive role that Africa and African people have played in their contributions to world affairs. It seeks to demonstrate how Africana people have reclaimed their own "story", noting that "until lions have their own historians, tales of hunting will always glorify the hunter."

Thus, the methodology of this course uses a paradigm which identifies the multiple levels of Black reality over time. The basic facts and perspectives of the course come from the synthesis of three main sources: Africana intellectual tradition, the traditional academic disciplines (particularly the humanities and social sciences), and the Black Studies Movement. The course is also concerned with the development of academic skills. Through lectures, discussions, documentary and feature films, students are guided to learn how to read and interpret the scholarly output of the field of Africana Studies, master key concepts, definitions and terminologies. In addition, students learn to express their understandings and reactions to the subject matter both verbally (oral presentations) and in writing in the mode associated with the discipline of Africana Studies.

POLS 322 China-Africa Relations
Non-major elective
Prerequisite(s): Written & Oral Communication, Text & Meaning
Typically offered in Semester Two
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The period from the 1990s has witnessed rapidly bourgeoning Sino-Africa ties, even though ties between them are not new. This is an interdisciplinary course intended to study the historical, economic, cultural, military, and political relations between the People's Republic of China and independent Africa. Employing a miscellany of primary source documents and secondary sources, the course will explore these interactions between China and Africa. We shall be particularly interested in a number of pertinent questions, including, does present-day Chinese engagement in Africa amount to a "new scramble for

Africa" or "neo-imperialism"? Is China a hegemonic power in Africa? What are the implications of the "Beijing Consensus", and how has China's embrace of market reform in the 1980s changed her economic and ideological ties with Africa? This course also investigates the nascent role of Chinese companies and businesses in a fast-developing Africa. The goal is to augment students' comprehension of the dynamics of China-Africa relations in a progressively globalized world.

POLS 234 Comparative Politics: Politics in Africa
Non-major elective
Prerequisite(s): Written & Oral Communication, Text & Meaning
Typically offered in Semester One
Course Type: Lecture
Credit Hours: 4; Ashesi Credit Units: 1; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This course is designed to study theoretically and empirically contemporary Politics of Africa. It is a study of African states and their domestic politics, laying emphasis on state-society interactions, governance, governing ideologies, forms of social (ethnic) and political pluralism, monopolization of political and economic power, popular resistance to power, connections, disruptions, and fractures from global politics, chronic underdevelopment and political repression of citizens, the rise of active polities, and the uses and abuses of cultural ties amid dynamism and pervasive violence. In fine, we shall interrogate the processes, institutions, ambiguities, antinomies and contradictions of African politics. The course also involves a study of the many theoretical and epistemological approaches developed to address the issues of African politics.

French Elective Courses

FRENC 111 Introductory French 1
Non-major elective
Prerequisite(s): None
Typically offered in Semester One and Semester Two
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The economic development being experienced by Ghana and the geographical location of the country (surrounded by francophone countries), its trade relations with its neighboring francophone countries, makes both the French language a fundamental means of communication in Ghana, especially in business and at all levels of business transactions**.** To be competent and competitive in the region, companies have understood that to be able to communicate, both in French and English is a plus, and that there is therefore a need to have bilingually trained staff.

In response to this need, Ashesi University has decided to offer its students, training in French, which will enable them to become « independent users » of French which means that they can easily survive in a francophone environment. The objective is to bring them to attain a level B1 or B2 of the CEFR (Common European Framework of Reference for Languages).

The Common European Framework divides learners into three broad divisions that can be divided into six levels: A1, A2, B1, B2, C1 & C2. For each level, it describes what a learner should be able to do in reading,

listening, speaking and writing. **We want our students who are taking the Introduction to French 1 class to get to meet the requirements of level A1**.

FRENC 122 Professional French 1
Non-major elective
*Prerequisite(s): Introductory French 2 or three years of JHS school French. (**Francophone are not allowed to take this course as it is a French as a Foreign Language course**)*
Typically offered in Semester Two
Offered: Fall
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The economic development being experienced by Ghana and the geographical location of the country (surrounded by francophone countries), its trade relations with its neighboring francophone countries, makes both the French language a fundamental means of communication in Ghana, especially in business and at all levels of business transactions**.** To be competent and competitive in the region, companies have understood that to be able to communicate both in French and English is a plus, and that there is therefore a need to have bilingually trained staff.

In response to this need, Ashesi University has decided to offer its students, training in French, which will enable them to become « independent users » of French which means that they can easily survive in a francophone environment. The objective is to bring them to attain a level B1 or B2 of the CEFR (Common European Framework of Reference for Languages). The Common European Framework divides learners into three broad divisions that can be divided into six levels: A1, A2, B1, B2, C1 & C2. For each level, it describes what a learner should be able to do in reading, listening, speaking and writing. **We want our students who are taking the Professional French 2 class to get to meet the requirements of level B1**.

FRENC 123 Introductory French 2
Non-major elective
Prerequisite(s): Introductory French 1 or three years of JHS school French. (**Francophone are not allowed to take this course as it is a French as a Foreign Language course**)
Typically offered in Semester One and Semester Two
Offered: Spring
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The economic development being experienced by Ghana and the geographical location of the country (surrounded by francophone countries), its trade relations with its neighboring francophone countries, makes both the French language a fundamental means of communication in Ghana, especially in business and at all levels of business transactions**.** To be competent and competitive in the region, companies have understood that to be able to communicate, both in French and English is a plus, and that there is therefore a need to have bilingually trained staff.

In response to this need, Ashesi University has decided to offer its students, training in French, which will enable them to become « independent users » of French which means that they can easily survive in a

francophone environment. The objective is to bring them to attain a level B1 or B2 of the CEFR (Common European Framework of Reference for Languages).

The Common European Framework divides learners into three broad divisions that can be divided into six levels: A1, A2, B1, B2, C1 & C2. For each level, it describes what a learner should be able to do in reading, listening, speaking, and writing. **We want our students who are taking the Intermediate French 2 class to go towards the requirements of level B1.**

FRENC 214 Professional French 2
Non-major elective
*Prerequisite(s): Professional French 1 or a test to three years of JHS school French. (**Francophones are not allowed to take this course as it is a French as a Foreign Language course**)*
Typically offered in the Semester Two
Offered: Spring
Course Type: Lecture
Ashesi Units: 1; Credit Hours: 4; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The economic development being experienced by Ghana and the geographical location of the country (surrounded by francophone countries), its trade relations with its neighboring francophone countries, makes both the French language a fundamental means of communication in Ghana, especially in business and at all levels of business transactions**.** To be competent and competitive in the region, companies have understood that to be able to communicate both in French and English is a plus, and that there is therefore a need to have bilingually trained staff.

In response to this need, Ashesi University has decided to offer its students, training in French, which will enable them to become « independent users » of French which means that they can easily survive in a francophone environment. The objective is to bring them to attain a level B1 or B2 of the CEFR (Common European Framework of Reference for Languages).

The Common European Framework divides learners into three broad divisions that can be divided into six levels: A1, A2, B1, B2, C1 & C2. For each level, it describes what a learner should be able to do in reading, listening, speaking and writing. **We want our students who are taking the Professional French 2 class to get to meet the requirements of level B1**.

FRENC 315 Francophone Literature, Films and Creative Writing
Non-major elective
*Prerequisite(s): Professional French 2 or a DELF B1 or a test in French. (**Francophones are allowed to take this course**)*
Typically offered in alternate years
Course Type: Lecture
Credit Hours: 4; Ashesi Credit Units: 1; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

This course introduces students to African literature written in French with emphasis on the work of major authors from West Africa and other authors parts of the Negritude movement. The study of diverse literary genres (Tales, epic, novel, short story, poetry, essay) will be supported by insights into the respective geographical, historical, linguistic, and societal context such as the triangular trade, the colonial era in Africa and the Negritude (Movement) School and its impact on African Literature.

In this course students will read and analyze books and books' extracts, watch and debate about films and documentaries for the period starting in 1940's and going up to the present. Through all those documents students will also learn about the Francophonie, the African francophone culture. Creative writing and writing with constrains will help students to improve their general and academic writing in French.

The course is an "Africana course" and will allow them to become more confident of their communication skills in French whether it is reading, writing, understanding or speaking.

This course is taught in French and is open for francophone students and/ or students who are advance users of French (at least a B1 level).

FRENC226 French Media and Communication
Non-major elective
Prerequisite(s): Introductory French 2 or French around the world of fashion, ***DELF A2***
Have an intermediate level in French (A2 level on the CECR grid here under)
Typically offered in alternate years
Course Type: Lecture
Credit Hours: 4; Ashesi Credit Units: 1; Hours per week classroom: 3; Hours per week discussion: 1
Hours of Study outside of the class (reading, assignments, studying, projects, and so on: 8 per week)

The focus of this course will be on the development of fluency and spontaneity of oral and written expression through radio animation. Student will have close interaction with various aspects of modern African francophone culture and during synchronous class discussions, students will be given the opportunity to formulate their opinions about current points of controversy in West Africa and report back on their online researches, while weekly written assignments (essays, synopsis, conductors, scripts) will help students improve their writing skills and prepare their final project: a 30 minutes radio program. For this course, students will surround themselves with aspects of everyday francophone west African culture: media (newspapers, radio, TV) pop culture (cinema, art festivals, music), and literature in order to simulate, as much as possible, complete immersion with oral and written comprehension.

We will also help students to take into account that today's media industry expands beyond traditional print (newspaper) and broadcast (Television and Radio) but also includes blogs, vlogs and social networking. As the most successful people in today's media are, whether they are doing media as a hobby, an engagement or professionally our students will not only get some skills in writing and speech, but they will also become excellent online and offline communicators and problem solvers. They will become innovative and entrepreneurial, bold and curios, open-minded and collaborative. By taking this course students will also gain a critical understanding of the media industry while acquiring technical and professional skills in French communication, information design and using them in the Ashesi Radio and beyond.

ECTS per Department

ECTS for Degree in Business Administration

Learning Activity	Learning Hours
Per Semester	
• In class instruction per course	42 hours (*3 hrs. X 14 weeks)*
• In class discussion associated with course	14 hours (*1 hr. X 14 weeks)*
• Out of class independent study associated with course instruction and discussion	112 hours (*[42 hrs. + 14 hrs.] X 2)*
TOTAL per course	168 hours
There is a minimum of 33.5 courses in a program for a degree	5,628 hours (*168 hours X 33.5)*
Experiential Learning per Program	
• Foundations of Design and Entrepreneurship I	60 hours
• Foundations of Design and Entrepreneurship II	60 hours
• Internship	160 hours
• Leadership IV	50 hours *(10 hrs. pre and post fieldwork + 40 hrs. fieldwork)*
• Capstone	140 hours
TOTAL hours of learning per program	6098 hours
ECTS (using 1 ECT = 25 hours)	**Approx. 244 ECTS**

ECTS for Degree in Engineering

Learning Activity	Learning Hours
Per Semester	
• In class instruction per course	42 hours *(3 hrs. X 14 weeks)*
• In class lab associated with major course	28 hours *(2 hr. X 14 weeks)*
• In class discussion associated with general courses	14 hours *(1 hr X 14 weeks)*
• Out of class independent study associated with major course instruction and discussion	140 hours *([42 hrs. + 28 hrs.] X 2)*
• Out of class independent study associated with general course instruction and discussion	112 hours *([42 hrs. + 14 hrs.] X 2)*
TOTAL per major 16 courses	210 hours
TOTAL per general 18 courses	168 hours
There is a minimum of 16 major courses in a program for a degree	3,360 hours *(210 hours X 16)*
There is a minimum of 18 general courses in a program for a degree	3,024 hours *(168 hours X 18)*
Experiential Learning per Program	
• Foundations of Design and Entrepreneurship I	60 hours
• Foundations of Design and Entrepreneurship II	60 hours
• Internship	160 hours
• Leadership IV	50 hours *(10 hrs. pre and post fieldwork + 40 hrs. fieldwork)*
• Capstone	100 hours
TOTAL hours of learning per program	6,814 hours
ECTS (using 1 ECT = 25 hours)	**Approx. 273 ECTS**

ECTS for Degree in Computer Science and Information Systems

Learning Activity	Learning Hours
Per Semester	
• In class instruction per course	42 hours *(3 hrs. X 14 weeks)*
• In class discussion associated with major course	21 hours *(1.5 hrs. X 14 weeks)*
• In class discussion associated with general course	14 hours *(1 hrs. X 14 weeks)*
• Out of class independent study associated with major course instruction and discussion	126 hours *([42 hrs. + 21 hrs.] X 2)*
• Out of class independent study associated with general course instruction and discussion	112 hours *([42 hrs. + 14 hrs.] X 2)*
TOTAL per major course	189 hours
TOTAL per general course	168 hours
There is a minimum of 14 major courses in a program for a degree	2,646 hours *(189 hours X 14)*
There is a minimum of 19.5 general courses in a program for a degree	3,276 hours *(168 hours X 19.5)*
Experiential Learning per Program	
• Foundations of Design and Entrepreneurship I	60 hours
• Foundations of Design and Entrepreneurship II	60 hours
• Internship	160 hours
• Leadership IV	50 hours *(10 hrs. pre and post fieldwork + 40 hrs. fieldwork)*
• Capstone	100 hours
TOTAL hours of learning per program	6,352 hours
ECTS (using 1 ECT = 25 hours)	**Approx. 254 ECTS**

List of courses to be taken for graduation:

- Advanced Fundamentals [MAS]
  - Mathematical Tools I
  - Mathematical Tools II
  - Thermofluids
  - Computer Programming / Embedded Systems
  - Analog and Digital Electronics
  - Material Engineering
  - Signals and Systems
  - Dynamics
  - Statics and Solid Mechanics
  - Computational Methods
- Mechatronics [MSc]
  - Control Systems I
  - Control Systems II and Optimal Control
  - Introduction to Robotics and Mechatronics
  - System Identification and Modelling
  - Advanced Communication Systems and Internet of Things
  - Data Analysis and Machine Learning
- Engineering in Perspective [MSc]
  - Finance and Policy Making for Technology Innovation
  - Leading Teams
  - Corporate Responsibility and Sustainability
  - Reducing the Environmental Footprint of Society
  - Introduction to Development Economics
  - Sustainable Engineering
- Energy Systems [MSc]
  - Energy Systems I
  - Energy Systems and Mobility
- Production [MSc]
  - Manufacturing Processes
  - Process Engineering
  - Product Development
  - Reliability and Risk

Mathematical Tools I

This course covers mathematical concepts and techniques necessary to model, solve and discuss scientific problems - notably through ordinary differential equations. The key is the so-called mathematical modelling cycle, i.e. the translation of problems from outside of mathematics into mathematics, the study of the mathematical problems and the interpretation of the results in the original environment. The content will span from single-variable calculus and linear algebra to ordinary differential equations.

Mathematical Tools II

This course is continuation of Mathematical Tools I and the main focus is on multivariable calculus and partial differential equations. The goal of Mathematics II is to provide the mathematical foundations relevant for this paradigm. Differential equations are by far the most important tool for modelling and are therefore a main focus of the course.

Thermofluids

This course introduces to the fundamentals of thermodynamics and fluid dynamics. In particular, it introduces the 1st and 2nd law of thermodynamics, the concept of energy, properties of compressible substances, and the kinetic theory of gases.

Embedded Systems and Computer Programming

An embedded system is some combination of computer hardware and software, either fixed in capability or programmable, that is designed for a specific function or for specific functions within a larger system. The course covers theoretical and practical aspects of embedded system design and includes a series of lab sessions. The focus of this lecture is on the design of embedded systems using formal models and methods as well as computer-based synthesis methods.

Digital Electronics

The course provides basic knowledge and methods to understand and to design digital circuits and systems. The content of the course includes digital and analogue signals and their representation, boolean algebra, circuit analysis and synthesis, the MOS transistor, CMOS logic, static and dynamic behaviour, tristate logic, Karnough-Maps, hazards, binary number systems, and coding. Moreover, will be also covered combinational and sequential circuits and systems (boolean algebra, K-maps, etc.), memory building blocks and memory structures, programmable logic circuits, finite state machines, and architecture of microprocessors.

Material Engineering

This module provides fundamental training in the behavior and manufacturing properties of materials as well as an introduction to materials selection and design considerations as practiced in industry, including related concepts such as Design for Manufacturing and “green” design. The objectives of the course include, the understanding of the societal implications of materials development, the appreciation of the challenges in materials selection, following the economical aspect of process selection, and grasp that any material is much more than its chemical composition.

Signals and Systems

Signals arise in most engineering applications. They contain information about the behavior of physical systems. Systems respond to signals and produce other signals. In this course, we explore how signals can be represented and manipulated, and their effects on systems. We further explore how we can discover basic system properties by exciting a system with various types of signals. The course will cover discrete-time signals and systems, Fourier- and z-Transforms, frequency domain characterization of signals and systems, system identification, time series analysis, and filter design.

Dynamics

This course aims at providing a graduate level introduction into the identification and condition assessment of structural systems. Upon completion of the course, the students will be able to: Test Structural Systems for assessing their condition, as this is expressed through stiffness, analyse sensor signals for identifying characteristic structural properties, such as frequencies, mode shapes and damping, based on noisy or incomplete measurements of the structural response, Establish relationships governing structural response (e.g. dynamics equations), Identify possible damage into the structure by picking up statistical changes in the structural "signature" (behavior).

Statics and Solid Mechanics

The course revisits the basic concepts of forces and mechanical power, and introduces methods for the analysis of statics problems: distributed forces, center of gravity, equilibrium, principle of virtual power, trusses, frames, forces and moments in beams and cables, friction. For the mechanical design of deformable bodies, the concepts of stress and deformations and introduced, thus allowing the formulation of the basic problem of continuum mechanics. Different constitutive models are discussed, including anisotropic linear elasticity, linear viscoelasticity, plasticity, viscoplasticity. The course will cover basic structural theories and their applications for the analysis of structural stability and fatigue problems.

Computational Methods

This module introduces numerical methods and techniques for solving initial boundary value problems in solid mechanics (heat conduction, static and dynamic mechanics problems of solids and structures), finite difference methods, indirect and direct techniques, variational methods, finite element (FE) method, FE analysis in small strains for applications in structural mechanics and solid mechanics.

MSc Curriculum: Semester-by-semester structure/schedule of course

Semester	Course Code	Module	Credit Hours (TPC)
Year 1			
Sem. 1: Sep – Jan	MECH 581	Analysis and Design of Control Systems	(2,2,3)
	MECH 521	Data Analysis and Machine Learning	(2,2,3)
	MECH 501	Leading Teams*	(2,0,2)
	MECH 531	Energy Systems	(2,2,3)
	MECH 503	Corporate Responsibility & Sustainability*	(2,0,2)
	MECH 511	Reliability and Risk	(2,2,3)
		Semester 1 total credit	16
Sem. 2: Jan – May	MECH 582	Optimal Control	(2,2,3)
	MECH 584	Robotics	(1,2,2)
	MECH 586	Mechatronics	(1,2,2)
	MECH 502	Reducing Societal and Environmental Footprint*	(2,0,2)
	MECH 532	Energy Systems and Mobility	(2,2,3)
	MECH 542	Process Engineering	(2,2,3)
	MECH 504	Finance and Policy for Technology Innovation*	(2,0,2)
		Semester 2 total credit	17
Year 2			
Sem. 1: Sep – Jan	MECH 681	System Identification and Modelling	(2,2,3)
	MECH 611 MECH 613	*Electives: (1 of these)* Sustainable Engineering Process Improvement & Optimization	(2,2,3)
	MECH 631 MECH 633	*Electives: (1 of these)* Advanced Communication Systems and Internet of Things Automation and Production Systems	(2,2,3)
	MECH 601	Development Economics	(2,0,2)
	MECH 613 MECH 651	*Electives: (1 of these)* Product Development Machine Tools (Jigs, Fixtures and Tools) Design	(2,2,3)
	MECH 641 MECH 645	*Electives: (1 of these)* Manufacturing Processes Food Production Technology	(2,2,3)
		Semester 1 subtotal	17
Sem. 2: Jan – May	MECH 690	Internship Master Thesis	4 6
		Total Program Credit	**60**

1) **Course Description:**

Provide short description of the content of the courses in the programme to include:

MECH 581 Analysis and Design of Control Systems (2,2,3)

a. *Objective*

The students will learn how to analyse systems and synthetize controllers for linear time invariant systems with one input and one output signal.

b. *Content*

- Modelling and linearization of dynamic systems with single input and output signals; State-space description; Analysis (stability, reachability, observability, etc.) of open-loop systems; Laplace transformation; Systems analysis in the frequency domain; Transfer functions and analysis of the influence of its poles and zeros on the system's dynamic behaviour. Frequency response; Analysis of closed-loop systems using the Nyquist criterion; Formulation of performance constraints; Specification of closed-loop system behaviour; Synthesis of elementary closed-loop control systems; Proportional-Integral-Derivative (PID) controllers; Lead/lag compensation; Loop shaping; Discrete time state space representation and stability analysis

MECH 582 Optimal Control (2,2,3)

a. *Objective*

This course focuses on the theory and practice of advanced control techniques like state feedback, linear multi-variable control systems, and model predictive control.

b. *Content*

- Extension of the basic SISO ideas (time and frequency domain, controllability, observability, eigenvalues, poles, zeros, frequency response, etc.) to MIMO systems; Design of state feedback controllers in time domain; Pole allocation; Finite-horizon LQR; Infinite-horizon LQR; Design of state observers and observer-based controllers with state feedback; LQG approaches; Invariance; Nominal Model Predictive Control; Tracking Model Predictive Control; Stability and robustness analysis of Model Predictive Control; Robust Model Predictive Control

MECH 584 Robotics (1,2,2)

a. *Objective*

This to introduce the fundamentals of robotic systems, including kinematics and dynamics as applied to manipulators and mobile robots.

b. *Content*

- Manipulators; Kinematics; Actuators, sensors, and simple sensor processing algorithm; Trajectory planning; Motion control; Teleoperation, Master-slave systems - Supervisory control - Latency problems. Vision Systems; Path Planning

MECH 586 Mechatronics (1,2,2)

a. *Objective*

By the end of the course, the students will be able to independently choose, design and integrate these different building blocks into a working mechatronic system.

b. *Content*

Over the course, the lecture topics will include an overview of

- Robotics in the mechatronics context; An introduction to different types of sensors and their use; Data acquisition; Microcontrollers programming; Interfacing embedded computers with the real world; Digital signal filtering; Digital signal processing; Introduction to different types of actuators and their use; An overview of computer vision; Forward and inverse kinematics in mechatronics systems; Control strategies for mechatronics systems; Human-Robot interaction.

MECH 681 System Identification and Modelling (2,2,3)

a. *Objective*

Learn how to mathematically describe a physical system or a process in the form of a model usable for analysis and control purposes.

b. *Content*

- Introduction to system modelling for control. First principles modeling; Lagrangian modeling; Energy-based methods. Model parametrization; Parameter estimation; Data fitting and statistics; Least-squares estimation; Frequency-domain identification; Time-domain identification; Prediction error methods; ARX Models; Closed-loop identification.

MECH 631 Advanced Communication Systems and Internet of Things (2,2,3)

a. *Objective*

The objective of this course is to provide an understanding of the principles for transport technologies for modern communications networks and architectures as well as the Internet of Things.

b. *Content*

The course will cover:

- protocol layers (both computing & IoT environment); delay, loss, throughput; routing algorithms; ethernet, switching, link layer; LANs, Constrained node networks; Internet protocol, Forwarding, Internet routing, routing policies, BGP challenges, and solutions; TCP protocol; DNS, HTTP, IPv6; FieldBus, Modbus, Profibus, Profinet, Powerlink Ethernet, CANOpen; Constrained devices; Communications channels as adapted for IoT including 802.15.4 variants, (Zigbee, 6LoWPAN, WirelessHart, etc) NB-IoT, Bluetooth, Cellular, PLC, VLC et; Protocols suited for IoT: Technologies for IoT: IoT sensors, MCU, communication modules, database technologies, data mining technologies, and hosting, visualization; Programming for IoT Data Collection and Communication; Industrial Internet of Things protocols; IoT Security

MECH 521 Data Analysis and Machine Learning (2,2,3)

a. *Objective*

The course will introduce the foundations of learning and making predictions from data. We will discuss important machine learning algorithms used in practice and provide hands-on experience in a course project.

b. *Content*

The course will cover:

- Linear regression; Overfitting; Cross-validation/bootstrap; Model selection; Regularization; [Stochastic] gradient descent; Linear classification; Logistic regression; Feature selection; Sparsity; Multi-class classification; Kernels and the kernel trick;

Properties of kernels and applications to linear and logistic regression; K-nearest neighbour; Neural networks; Backpropagation; Regularization; Convolutional neural networks; Unsupervised learning; K-means; PCA; Neural network autoencoders; The statistical perspective (regularization as prior; loss as likelihood; learning as MAP inference); Statistical decision theory (decision making based on statistical models and utility functions); Discriminative vs. generative modelling (benefits and challenges in modelling joint vs conditional distributions); Bayes' classifiers (Naive Bayes, Gaussian Bayes; MLE); Bayesian approaches to unsupervised learning (Gaussian mixtures, EM).

MECH 504 Finance and Public Policy for Engineers (2,0,2)

a. *Objective*

This course will provide engineering students with basic knowledge on finance and public policy related to technology and innovation. It will have a particular focus on developing country-specific finance and policy aspects.

b. *Content*

- Evaluation and financing of capital projects. Methods taught include investment appraisal; cost-effectiveness analysis, cost-benefit analysis; technological forecasting, expert elicitation; cash flows for a project; time value of money; evaluation criteria for investment decisions, taxation; sensitivity, scenario, and other decision analysis techniques; risk and return, sources of finance for projects, etc. Hands-on case studies, in which the students take an investor's or policy maker's role.

MECH 501 Leading Teams (2,0,2)

a. *Objective*

This course will provide an understanding of the basic HRM functions and their relationship to leadership and how to manage team processes and diversity.

b. *Content*

- The policies, practices, and systems that influence employees' behaviour, attitudes, and performance. Practical instruments supporting leadership functions; basic HRM functions and their relationship to leadership; instruments for selection, performance appraisal, compensation, management, and personnel development (from team leader's perspective); leadership requirements and success factors in leadership; fundamental processes in teams; how to manage team processes and diversity; Fundamentals of effective leadership and dynamics in teams. semester projects to apply HRM instruments in company contexts.

MECH 611 *Sustainable Engineering (2,2,3)*

a. *Objective*

Students will learn a holistic approach of sustainable development. Ecological, economic, and social constraints will be presented, and students will learn about methods for argumentation and tools for assessment) that influence our built environment. An objective is to address current challenges of climate change mitigation and resource depletion.

b. *Content*

The following topics give an overview of the themes that are to be worked on during the lecture:

- history and emergence of sustainable development; current understanding and definition of sustainable development. the role of cities, urbanisation and material resources (i.e. energy, construction material) in social economic and environmental sustainability; role of stakeholders, their motivations and constraints; how to evaluate challenges, identify deficits and define strategies to promote a more sustainable construction. Method 1: Life cycle assessment (planning, construction, operation/use, deconstruction). Method 2: Life Cycle Costing. Method 3: Labels and certification. Operation energy at building, urban and national scale, mobility and density questions, and embodied energy for developing and developed world. theory and application of current scientific pathways towards sustainable development.

MECH 601 Development Economics (2,0,2)

a. *Objective*

The goal of this course is to provide students with a basic understanding of both theories and empirics on poverty, growth and inequality. Based on this understanding, important policies for sustainable economic development and poverty reduction are discussed, with a focus on the role of technological innovations.

b. *Content*

- How development can be defined and measured – building on Sen's capability approach. Classical and endogenous growth theory and the role of capital, technological innovation, governance, education, and health for economic development. How various forms of market failures lead to environmental destruction and extreme poverty and the policies that are needed by a state to confront it. The role of globalization for the future development of countries in sub-Saharan Africa will be discussed.

MECH 502 Reducing Societal and Environmental Footprint (2,0,2)

a. *Objective*

The objectives of this course are to (1) gain an overview of relevant questions in the area of international environmental politics from a social sciences viewpoint; (2) learn how to identify interesting/innovative questions concerning this policy area and how to answer them in a methodologically sophisticated way; (3) gain an overview of important global and regional environmental problems and how they could be solved.

b. *Content*

This course deals with how and why international cooperation in environmental politics emerges, and under what circumstances such cooperation is effective and efficient. Based on theories of international political economy and theories of government regulation various examples of international environmental politics to be discussed include:

- the management of international water resources; political responses to global warming; the protection of the stratospheric ozone layer; the reduction of long-range transboundary air pollution; protection of biodiversity; how to deal with plastic waste; the prevention of pollution of the oceans, etc.

MECH 503 Corporate Responsibility & Sustainability (2,0,2)

a. *Objective*

This course introduces approaches to corporate social responsibility. It will address questions such as -What is the responsibility of companies to contribute to society, if any? How can companies integrate their responsibility into the business model and along the supply chain?

b. Content

The course will cover international soft-laws or self-regulation instruments, and discuss the challenges companies face when implementing corporate social responsibility in business operations.

MECH 531 Energy Systems (2,2,3)

a. Objective

Students learn the potential and limitations of renewable energy technologies and their contribution towards sustainable energy utilization.

b. Content

Engineering aspects of energy conversion for

solar thermal, solar photovoltaics, biomass, wind, geothermal, hydro, and waste-to-energy technologies. Technologies for energy optimization

MECH 532 Energy Systems and Mobility (2,2,3)

a. Objective

This course provides an introduction to current and future propulsion systems behaviour, focussing on energy generation and utilisation. It addresses electrical aspects of energy engineering and topics in renewable energy. Moreover, it will also cover system optimization and controller design for vehicles.

b. Content

- Physical description and mathematical models of components and subsystems; Power utilization; Power electronics; Propulsion; load control; supercharging, emissions; drive train components; HV & LV power distribution.

MECH 641 Manufacturing Processes (2,2,3)

a. Objective

The course discusses fundamental terms of production engineering and process chain planning.

b. Content

- Basic principles of manufacturing techniques; functionality of a manufacturing shop. Plastic deformation- and separative- manufacturing processes; laser machining (welding and cutting) and their layouts, product defining properties; limitations of applications such as the associated workshop facilities; principles of the industrial measurement technique; mechatronics concepts in machine tool construction; quality assurance,

MECH 542 Process Engineering (2,2,3)

a. Objective

Students should be able to evaluate and design biological, chemical (or similar) processes, and develop simple mathematical models to simulate the processes.

b. Content

- biological and chemical processes used (e.g. in wastewater treatment, organic waste management, and biological resource recovery. Also, an overview of other common industrial processes. Fundamental principles of biological and chemical processes;

process design based on kinetic and stoichiometric principles, e.g., anaerobic digestion for biogas production and aerobic wastewater treatment. Process technologies, equipment, and systems; Industrial Processes; Process technology operations; Quality, Safety, Health, and Environment

MECH 613 Product Development (2,2,3)

a. *Objective*

The course introduces students to the product development process. Students will in a team, explore the early phases of conceptual development and product design, from ideation and concept generation through to hands-on prototyping.

b. *Content*

- Introduction to product development and engineering design; product planning and social-economic-technology (SET) factors; user-centered design and product specification; concept generation and selection methods; system design and embodiment design; hands-on prototyping and prototype planning; material selection in engineering design; product lifecycle and sustainability; design for manufacture and design for additive manufacture.

MECH 511 Reliability and Risk(2,2,3)

a. *Objective*

Students will be able to model complex technical systems and critical infrastructures, including their dependencies and interdependencies, with appropriate numerical methods. At the end, they will be able to propose design improvements and protection/mitigation strategies to reduce the risks and vulnerabilities of these systems.

b. *Content*

Preamble: Modern technical systems and critical infrastructures are complex, highly integrated and interdependent. Examples of these are highly integrated energy supply, energy supply with high penetrations of renewable energy sources, communication, transport, and other physically networked critical infrastructures that provide vital social services. As a result, standard risk-assessment tools are insufficient in evaluating the levels of vulnerability, reliability, and risk. This course offers suitable.

- Analytical models and computational methods to evaluate levels of vulnerability, reliability, and risk with scientific accuracy. Introduction to complex technical systems and critical infrastructures; basics of the Markov approach to system modelling for reliability and availability analysis; Monte Carlo simulation for reliability and availability analysis, Markov Chain Monte Carlo for applications to reliability and availability analysis, dependent, common cause and cascading failures; complex network theory for the vulnerability analysis of complex technical systems and critical infrastructures; basic concepts of uncertainty and sensitivity analysis in support of the analysis of the reliability and risk of complex systems under incomplete knowledge of their behaviour,

ASHESI