

# Engineering Design

## ACADEMIC SKILLS

### AA SPEAKING AND LISTENING

AA1 Utilize effective verbal and non-verbal communication skills

AA2 Participate in conversation, discussion, and group presentations

AA3 Communicate and follow directions/procedures

AA4 Communicate effectively with customers and co-workers

### AB READING AND WRITING

AB1 Locate and interpret written information

AB2 Read and interpret workplace documents

AB3 Identify relevant details, facts, and specifications

AB4 Record information accurately and completely

AB5 Demonstrate competence in organizing, writing, and editing using correct vocabulary, spelling, grammar, and punctuation

AB6 Demonstrate the ability to write clearly and concisely using industry specific terminology

### AC CRITICAL THINKING AND PROBLEM SOLVING

AC1 Utilize critical-thinking skills to determine best options/outcomes (e.g., analyze reliable/unreliable sources of information, use previous experiences, implement crisis management, develop contingency planning)

AC2 Utilize innovation and problem-solving skills to arrive at the best solution for current situation

AC3 Implement effective decision-making skills

### AD MATHEMATICS

AD1 Perform basic and higher level math operations (e.g., addition, subtraction, multiplication, division, decimals, fractions, units of conversion, averaging, percentage, proportion, ratios)

AD2 Solve problems using measurement skills (e.g., distance, weight, area, volume)

AD3 Make reasonable estimates

AD4 Use tables, graphs, diagrams, and charts to obtain or convey information

AD5 Use deductive reasoning and problem-solving in mathematics

## **AE FINANCIAL LITERACY**

AE1 Locate, evaluate, and apply personal financial information

AE2 Identify the components of a budget and how one is created

AE3 Set personal financial goals and develop a plan for achieving them

AE4 Use financial services effectively

AE5 Demonstrate ability to meet financial obligations

## **AF INTERNET USE AND SECURITY**

AF1 Recognize the potential risks associated with Internet use

AF2 Identify and apply Internet security practices (e.g., password security, login, logout, log off, lock computer)

AF3 Practice safe, legal, and responsible use of technology in the workplace

## **AG INFORMATION TECHNOLOGY**

AG1 Use technology appropriately to enhance professional presentations

AG2 Demonstrate effective and appropriate use of social media

AG3 Identify ways social media can be used as marketing, advertising, and data gathering tools

## **AH TELECOMMUNICATIONS**

AH1 Select and use appropriate devices, services, and applications to complete workplace tasks

AH2 Demonstrate appropriate etiquette when using e-communications (e.g., cell phone, e-mail, personal digital assistants, online meetings, conference calls)

# EMPLOYABILITY SKILLS

## EA POSITIVE WORK ETHIC

EA1 Demonstrate enthusiasm and confidence about work and learning new tasks

EA2 Demonstrate consistent and punctual attendance

EA3 Demonstrate initiative in assuming tasks

EA4 Exhibit dependability in the workplace

EA5 Take and provide direction in the workplace

EA6 Accept responsibility for personal decisions and actions

## EB INTEGRITY

EB1 Abide by workplace policies and procedures

EB2 Demonstrate honesty and reliability

EB3 Demonstrate ethical characteristics and behaviors

EB4 Maintain confidentiality and integrity of sensitive company information

EB5 Demonstrate loyalty to the company

## EC SELF-REPRESENTATION

EC1 Demonstrate appropriate dress and hygiene in the workplace

EC2 Use language and manners suitable for the workplace

EC3 Demonstrate polite and respectful behavior toward others

EC4 Demonstrate personal accountability in the workplace

EC5 Demonstrate pride in work

## ED TIME, TASK, AND RESOURCE MANAGEMENT

ED1 Plan and follow a work schedule

ED2 Work with minimal supervision

ED3 Work within budgetary constraints

ED4 Demonstrate ability to stay on task to produce high quality deliverables on time

## **EE DIVERSITY AWARENESS**

EE1 Recognize diversity, discrimination, harassment, and equity

EE2 Work well with all customers and co-worker

EE3 Explain the benefits of diversity within the workplace

EE4 Explain the importance of respect for feelings, values, and beliefs of others

EE5 Identify strategies to bridge cultural/generational differences and use differing perspectives to increase overall quality of work

EE6 Illustrate techniques for eliminating gender bias and stereotyping in the workplace

EE7 Identify ways tasks can be structured to accommodate the diverse needs of workers

EE8 Recognize the challenges and advantages of a global workforce

## **EF TEAMWORK**

EF1 Recognize the characteristics of a team environment and conventional workplace

EF2 Contribute to the success of the team

EF3 Demonstrate effective team skills and evaluate their importance in the workplace (e.g., setting goals, listening, following directions, questioning, dividing work)

## **EG CREATIVITY AND RESOURCEFULNESS**

EG1 Contribute new ideas

EG2 Stimulate ideas by posing questions

EG3 Value varying ideas and opinions

EG4 Locate and verify information

## **EH CONFLICT RESOLUTION**

EH1 Identify conflict resolution skills to enhance productivity and improve workplace relationships

EH2 Implement conflict resolution strategies and problem-solving skills

EH3 Explain the use of documentation and its role as a component of conflict resolution

## **EI CUSTOMER/CLIENT SERVICE**

EI1 Recognize the importance of and demonstrate how to properly acknowledge customers/clients

EI2 Identify and address needs of customers/clients

EI3 Provide helpful, courteous, and knowledgeable service

EI4 Identify appropriate channels of communication with customers/clients (e.g., phone call, face-to-face, e-mail, website)

EI5 Identify techniques to seek and use customer/client feedback to improve company services

EI6 Recognize the relationship between customer/client satisfaction and company success

## **EJ ORGANIZATIONS, SYSTEMS, AND CLIMATES**

EJ1 Define profit and evaluate the cost of conducting business

EJ2 Identify "big picture" issues in conducting business

EJ3 Identify role in fulfilling the mission of the workplace

EJ4 Identify the rights of workers (e.g., adult and child labor laws and other equal employment opportunity laws)

EJ5 Recognize the chain of command, organizational flow chart system, and hierarchy of management within an organization

## **EK JOB ACQUISITION AND ADVANCEMENT**

EK1 Recognize the importance of maintaining a job and pursuing a career

EK2 Define jobs associated with a specific career path or profession

EK3 Identify and seek various job opportunities (e.g., volunteerism, internships, co-op, part-time/full-time employment)

EK4 Prepare a resume, letter of application, and job application

EK5 Prepare for a job interview (e.g., research company, highlight personal strengths, prepare questions, set-up a mock interview, dress appropriately)

EK6 Participate in a job interview

EK7 Explain the proper procedure for leaving a job

## **EL LIFELONG LEARNING**

EL1 Acquire current and emerging industry-related information

EL2 Demonstrate commitment to learning as a life-long process and recognize learning opportunities

EL3 Seek and capitalize on self-improvement opportunities

EL4 Discuss the importance of flexible career planning and career self-management

EL5 Employ leadership skills to achieve workplace objectives (e.g., personal vision, adaptability, change, shared vision)

EL6 Recognize the importance of job performance evaluation and coaching as it relates to career advancement

EL7 Accept and provide constructive criticism

EL8 Describe the impact of the global economy on jobs and careers

## **EM JOB SPECIFIC TECHNOLOGIES**

EM1 Identify the value of new technologies and their impact on driving continuous change and the need for life-long learning

EM2 Research and identify emerging technologies for specific careers

EM3 Select appropriate technological resources to accomplish work

## **EN HEALTH AND SAFETY**

EN1 Assume responsibility for safety of self and others

EN2 Follow safety guidelines in the workplace

EN3 Manage personal health and wellness

# OCCUPATIONAL SKILLS

## OA GENERAL LAB SAFETY RULES AND PROCEDURES

OA1 Describe general shop safety rules and procedures

OA2 Demonstrate knowledge of OSHA and its role in workplace safety

OA3 Comply with the required use of personal protection equipment (PPE) (i.e., safety glasses, ear protection, gloves, shoes) during lab/shop activities

OA4 Utilize safe procedures for handling of tools and equipment

OA5 Operate lab equipment according to safety guidelines

OA6 Identify and use proper lifting procedures and proper use of support equipment

OA7 Utilize proper ventilation procedures for working within the lab/shop area

OA8 Identify marked safety areas and colors

OA9 Identify the location and the types of fire extinguishers and other fire safety equipment, as well as, demonstrating the procedures for usage

OA10 Identify the location and use of eye wash stations

OA11 Identify the location of the posted evacuation routes

OA12 Identify and wear appropriate clothing for lab/shop activities

OA13 Secure hair and jewelry for lab/shop activities

OA14 Demonstrate knowledge of the safety aspects of low and high voltage circuits

OA15 Locate and interpret material safety data sheets (MSDS)

OA16 Perform housekeeping duties

OA17 Follow verbal instructions to complete work assignments

OA18 Follow written instructions to complete work assignments

OA19 Demonstrate ergonomically safe use of lab equipment, furniture and materials

## OB HAND TOOLS

OB1 Identify hand tools and their appropriate usage

OB2 Demonstrate the proper techniques when using hand tools

OB3 Demonstrate safe handling and use of appropriate tools

OB4 Demonstrate proper cleaning, storage and maintenance of tools

## OC POWER TOOLS AND EQUIPMENT

OC1 Identify power tools/equipment (e.g., band saw, drill press, table saw, sanders, portable power tools) and their appropriate usage

OC2 Demonstrate safe and proper techniques when using power tools and equipment

OC3 Demonstrate proper cleaning, storage and maintenance of power tools and equipment

OC4 Choose correct machining processes(s) based on the given/produced design

## OD HISTORY OF STEM

OD1 Define Science, Technology, Engineering and Mathematics (STEM) and their relationship to each other

OD2 Identify engineering & technology achievements (e.g., space race, computer technology, aqua ducts, skyscrapers, bridges, subways, airports) throughout history

OD3 Identify famous inventors (e.g., Edison, Tesla, Bell, da Vinci, Washington Carver, Ford) and their achievements throughout history

OD4 Research how historical period and regional style have influenced engineering design

OD5 Investigate the evolution of a product

OD6 Describe the product life cycle

OD7 Describe how your design effects the environment both in a positive and negative way

## OE CAREERS IN STEM

OE1 Investigate STEM careers, training, professional organizations and associated opportunities

OE2 Describe the difference between Engineering and Engineering Technology disciplines and job functions

OE3 Explore career opportunities and list the educational requirements for several STEM fields of interest

OE4 Research STEM Fields including non-traditional career paths to understand workload, education, job outlook and salary

OE5 Research STEM education and its role in workforce development

OE6 Identify top KY occupations as they relate to industry sectors

OE7 Utilize KCEWS Future Skills Report to determine future workforce demand in STEM fields



OE8 Research the pros/cons of STEM careers and what their impact is on the Kentucky workforce and on job transitions

OE9 Investigate state and national professional organizations (i.e., KSPE, SAME, NCSEA, SME, NAM, NSPE, ASCE, ABET, SWE, NSBE, LEED, PMP, SHPE) and their importance to fields of engineering

## OF ETHICS IN ENGINEERING

OF1 Identify current professional engineering codes of ethics

OF2 Analyze ethical engineering issues

OF3 Analyze and explain ethical and technical issues contributing to an engineering disaster

OF4 Describe how ethics influences the engineering process

OF5 Describe the negative impacts technology can have on the environment

OF6 Connect with Engineering and Engineering Technology professionals in your community to discuss engineering ethics

OF7 Identify various standards organizations (i.e., OSHA, EPA, ACS) and their importance in fields of engineering

## OG ENGINEERING DESIGN PROCESS

OG1 Identify several design processes and evaluate pros/cons of each

OG2 Explain how a design process is a systematic, iterative problem-solving method that produces solutions to meet human needs and wants

OG3 Identify the activities that occur during each phase of a design process

OG4 Specify criteria and identify constraints when defining a problem and determine the most appropriate solution considering time, material, cost and regulations

OG5 Apply the steps of a design process to solve a variety of design problems

OG6 Describe how social, environmental, legal and financial constraints influence a design process

OG7 Utilize conceptual, mathematical and physical models to evaluate design solutions

OG8 Incorporate computer technology to assist in organizing and analyzing data used during a design process

OG9 Document various design process solutions and communicate to the intended audience

OG10 Utilize a cost analysis tool during the design process

OG11 Identify and implement codes and specifications (i.e., AASHTO, IBC, RBC, AISC, ACI, PCI, AISI, NDS, TMS, ASTM, OSHA, ADA, LEED, ASHRE) based on the intended design solution

OG12 Adapt and change as problems arise in the design process

OG13 Demonstrate best practices when working through the design process on a team

OG14 Incorporate ergonomics within each design solution

## **OH UTILIZE A DIGITAL PORTFOLIO TO APPLY THE ENGINEERING DESIGN PROCESS**

OH1 Present and justify the problem

OH2 Document and analyze prior solution(s) attempt

OH3 Present and justify a solution design requirements

OH4 Design concept generation, analysis and selection

OH5 Apply STEM principles and practices

OH6 Consider design viability

OH7 Construct of a testable prototype

OH8 Develop a prototype testing and data collection plan

OH9 Test data collection and analysis

OH10 Document external evaluations

OH11 Reflect on the design process

OH12 Present the designer's recommendations

OH13 Present the project portfolio

OH14 Write like an engineer

## **OI FREEHAND TECHNICAL SKETCHING TECHNIQUES**

OI1 Develop design ideas using freehand sketching

OI2 Identify the six primary orthographic views

OI3 Create pictorial and multi-view sketches

OI4 Create rough, refined and presentation sketches

OI5 Utilize the alphabet of lines (i.e., styles and weights)

OI6 Legibly annotate sketches

OI7 Interpret common symbols and terminology

## **OJ MEASURING AND SCALING TECHNIQUES**

OJ1 Identify industry standard units of measure

OJ2 Convert between industry standard units of measure

OJ3 Determine and apply the appropriate engineering and metric scales

OJ4 Determine and apply the equivalence between fractions and decimals

OJ5 Demonstrate proper use of precision measuring tools

OJ6 Make precision measurements to the degree of accuracy required by the specifications using appropriate instruments

OJ7 Measure effectively and accurately to accomplish engineering-related tasks

OJ8 Utilize geometric dimensioning and tolerancing to solve engineering problems

## **OK ENGINEERING DOCUMENTATION AND COMMUNICATION PROCEDURES**

OK1 Demonstrate record keeping procedures and communication in engineering utilizing an engineering notebook

OK2 Identify the importance of proprietary documentation in engineering

OK3 Utilize project management timelines in a Gantt chart

OK4 Present design solutions in a clear and concise manner

OK5 Demonstrate the conventions of technical writing to communicate design solutions

OK6 Document object size, area, mass, volume and density

OK7 Utilize appropriate digital file management techniques

OK8 Utilize appropriate presentation techniques

OK9 Identify basic components of a computer system and their function

OK10 Use spreadsheet software to analyze and present data

OK11 Communicate project results through a technical report

OK12 Create a portfolio containing all notes, work and projects documenting the course

OK13 Communicate to a non-technical audience your project solution

## **OL COMPUTER AIDED DESIGN (CAD) SYSTEM**

OL1 Identify various 2D and 3D CAD software

OL2 Interpret basic elements of a technical drawing (i.e., title block information, dimensions, line types)

OL3 Describe and construct various types of CAD drawings (i.e., part, assembly, drawing files)

OL4 Construct drawings utilizing metric and customary (i.e., SAE and Imperial) measurement systems

OL5 Arrange dimensions and annotations using appropriate standards (i.e., ANSI and ISO)

OL6 Read technical drawings identifying and understand the dimensional tolerances and limits

OL7 Construct exploded assembly drawings with part lists and balloons

OL8 Create rendered drawings

OL9 Utilize a CAD modeling system to perform a physical property analysis (i.e., quantities, take offs, area, mass, weight) for a part or assembly

OL10 Calculate costs and physical requirements impacted by product physical properties of a product

OL11 Use appropriate technology (i.e., camera, video) to allow a walkthrough of a project

## OM MODELING TECHNIQUES

OM1 Identify the areas of modeling (i.e., physical, conceptual, mathematical)

OM2 Create various mock-ups, scale models and working prototypes based on CAD drawings

OM3 Evaluate various mock-ups, scale models and working prototypes using a design process

OM4 Design simulations to model intended design outcomes

OM5 Create virtual walk throughs and fly overs to model intended design outcomes

OM6 Describe the difference between additive and subtractive modeling

## ON RAPID PROTOTYPING TECHNOLOGY

ON1 Explain how technology shifts throughout history have made rapid prototyping possible

ON2 Explain current and emerging rapid prototyping applications in a variety of industries

ON3 Describe the advantages and limitations of each rapid prototyping technology

ON4 Evaluate real-life scenarios and recommend the appropriate use of rapid prototyping technology

ON5 Identify opportunities to apply rapid prototyping technology for time and cost savings

ON6 Discuss the economic implications of rapid prototyping including its impact on startup businesses and supply chains

ON7 Determine appropriate rapid prototyping process to solve various design problems

ON8 Determine appropriate rapid prototyping material(s) to solve various engineering related problems

ON9 Demonstrate an understanding of rapid prototyping using a 3D printer to solve engineering related problems

ON10 Demonstrate an understanding of rapid prototyping using a laser engraver to solve engineering related problems

ON11 Demonstrate an understanding of rapid prototyping using a CNC equipment to solve engineering related problems

ON12 Demonstrate an understanding of rapid prototyping using breadboards and microcontrollers to solve engineering related problems

## **OO ARCHITECTURE AND BUILDING CONSTRUCTION**

OO1 Analyze the positive and negative environmental impacts of various design solutions

OO2 Develop architectural models (e.g., balsa structures, balsa residential framing model, foam board models, scale concrete foundations)

OO3 Define architecture and/or building construction

OO4 Research education and careers related to architecture and/or building construction

OO5 Describe the various residential/architectural styles

OO6 Describe the construction process from site acquisition to occupation

OO7 Investigate various architects throughout history, present their findings

OO8 Develop design presentations which may include; plan sets, cost analysis or estimations, renderings, materials and walkthroughs

OO9 Identify and describe heavy machinery used in various construction processes (i.e., dozers, excavators, graders, scrapers)

OO10 Identify various building, fire, ADA and safety codes

OO11 Apply various building, fire, ADA and safety codes

OO12 Identify specific community planning and zoning regulations

OO13 Apply specific community planning and zoning regulations

OO14 Prepare architectural drawings (e.g., floor plans, site plans, elevations) and prepare roof and demolition plans

## **OP CIVIL ENGINEERING**

OP1 Define civil engineering

OP2 Identify the primary duties and attributes of a civil engineer

OP3 Differentiate the relationships of all stakeholders involved in a civil engineering project

OP4 Discuss various traditional and non-traditional civil engineering career paths

## **OQ STRUCTURES**

OQ1 Identify various materials used in engineering structures

OQ2 Identify forces (e.g., tension, compression, torque, shear) that act on structures

OQ3 Construct various structure spans and calculate efficiency

OQ4 Research the different foundation types and uses for a commercial application

OQ5 Describe the different types of loads and how they affect a building design

OQ6 Determine live, dead and secondary loads

OQ7 Design beams to safely carry various loads

OQ8 Calculate beam deflection

OQ9 Utilize building codes to determine structural systems for a given building occupancy

## **OR GEOTECHNICAL**

OR1 Apply soil analysis techniques for construction applications

OR2 Identify types of soil and rocks found in certain geographical areas

OR3 Run soil samples with explanation of findings

OR4 Explain the importance of gradation during construction

## **OS SURVEYING**

OS1 Be able to identify survey equipment and their uses

OS2 Use survey equipment to plot and draw a topographical map of assigned area

OS3 Recognize emerging technology (i.e. drones, technical equipment/software) associated with surveying

## **OT CONCRETE**

OT1 Define concrete and its components

OT2 Calculate material properties (e.g., tensile, modulus of elasticity, compression) of concrete

OT3 Create and test concrete using student created formula

OT4 Create and test homemade concrete

OT5 Identify career opportunities in concrete

OT6 Calculate cost of defined building pad

## **OU BUILDING INFORMATION MODELING (BIM) & CITY INFORMATIONAL MODELING (CIM)**

OU1 Explain the purpose of building codes (e.g., IBC, ICC, NEC, ADA) and regulations

OU2 Outline typical components of a framing system

OU3 Identify and explain code requirements for structures

OU4 Utilize building codes to determine structural systems for a given building occupancy

OU5 Interpret HVAC, electrical, plumbing and mechanical systems construction documents

OU6 Create HVAC, electrical plumbing and mechanical systems construction documents

OU7 Identify conventional roof design

OU8 Research building materials that address aesthetics, design loads and environmental challenges

OU9 Model a building using architectural design software

OU10 Estimate cost for a construction project

OU11 Calculate the heat loss for a building

OU12 Research the use and application of different commercial floor systems, wall systems and roofing systems

## **OV URBAN PLANNING**

OV1 Explain the purpose of urban planning

OV2 Utilize client requirements and specifications to create a plan set

OV3 Explain how planning projects fits into the community culture

OV4 Create a plan set

OV5 Identify land use and development regulations

OV6 Research energy conservation techniques

OV7 Identify land use and development regulations for commercial parking lots

OV8 Research codes, zoning ordinances and regulations for a commercial design

## OW STATICS

OW1 Draw complete free-body diagrams of static systems

OW2 Write appropriate equilibrium equations including the support reactions on a structure

OW3 Determine the resultant forces of a truss system

OW4 Apply the concepts of equilibrium to trusses

OW5 Calculate compression and tension forces on individual members in a truss system

OW6 Calculate moments, centers of mass and forces for particular structures

OW7 Calculate the moment of inertia of a structural member

OW8 Calculate the deflection of a structural member

OW9 Design and destructively test a truss to analyze calculated predictions of maximum load and efficiency

## OX MATERIAL PROPERTIES

OX1 Describe physical and mechanical properties of different materials (e.g., metals, ceramics, polymers and plastics, semiconductors, wood, composites)

OX2 Distinguish between stress and strain

OX3 Distinguish between elastic and plastic deformation

OX4 Identify different parts of the stress-strain curve for various materials

OX5 Define modulus of elasticity

OX6 Identify and calculate parts of a stress-strain curve using material test samples

OX7 Describe the relationship between the tensile force applied to a material and the deformation of the material

OX8 Compare and contrast use of a variety of a materials for a given application