

IGNITE: MASTERING MANUFACTURING

GENERAL OVERVIEW

IGNITE: Mastering Manufacturing is an innovative three-year high school curriculum that equips students with the mastery of manufacturing technologies, processes, and systems to prepare them for careers in the 21st-century production environment and/or for the continuation of their education. IGNITE blends interactive multimedia learning with virtual simulations and ensures that students master manufacturing because the program couples theory and concept learning with project-based experiences built around real industry problems and challenges. Activities focused on materials science, the foundation for all advanced manufacturing, are integrated into the IGNITE student experience. And, in the third year of the curriculum, students work in teams on a capstone project that uses industry-specific technology and equipment to solve real-world problems.

KEY PARTNERS & EARNED CREDENTIALS

The IGNITE curriculum development process was led by LIFT and included a team of global market leaders in their respective fields. Support was provided by the Department of Defense through a Manufacturing Engineering Education Program grant.

Amatrol built on their existing foundational manufacturing curriculum to create a blended learning curriculum for IGNITE that engages students through project-based problem solving and hands-on learning activities. Amatrol is the market leader in designing, developing and manufacturing technical learning systems, highly interactive eLearning, hands-on simulators and more, to train tomorrow's global workforce for a diverse set of industries.

Led by the PAST Foundation and in partnership with the Ohio State University and ASM Materials Education Foundation, a series of project-based activities was developed for IGNITE, providing an introduction to properties and processes of three broad categories of materials. PAST Foundation helps high schools and districts develop transformative learning strategies and provides intensive hands-on assistance to administrators and teachers in the implementation of those strategies.

Students who complete the three-year IGNITE: Mastering Manufacturing curriculum will be well-prepared for the Manufacturing Skills Standards Council (MSSC) Certified Production

Technician credential and will have foundational knowledge and skills toward national credentials in CNC Machine Operations Industrial Maintenance and Welding. IGNITE graduates also will be well-prepared to continue their education in engineering at the post-secondary level.

CURRICULUM DETAILS AND HOURS

IGNITE is a three-year high school curriculum that includes up to 130 hours of content each year. The curriculum is composed of three individual parts that, when blended together, become IGNITE: Mastering Manufacturing. Those three parts are:

- **Advanced Manufacturing Systems and Process.** IGNITE includes three Advanced Manufacturing Courses: Introduction to Advanced Manufacturing, Advanced Manufacturing Systems 1 and Advanced Manufacturing Systems 2. Attachment A lays out course descriptions and expected learning outcomes for each of these courses. Attachment B is a list of recommended equipment to support student learning.
- **Materials Science.** IGNITE also includes a series of Materials Science modules that can be integrated into the foundational manufacturing activities or into other courses the students are taking, such as math or science. Each of the four Materials Science modules can stand alone or can be used sequentially. Each module is bookended between kickoff brainstorming sessions and presentation of learning, with activities scheduled in between. Attachment C provides additional detail about the Materials Science modules.
- **Capstone Projects.** Each IGNITE student will participate in a capstone project in their third year. Capstones provide students the opportunity to work in teams solving real-world problems using new and emerging technologies. Attachment D is a description of each of the currently available capstone projects.

Throughout the IGNITE curriculum – in the Advanced Manufacturing Systems and Processes courses, in the Materials Science activities and as they work on their Capstone Projects – students will have the opportunity to learn and practice Common Employability Skills. Common Employability Skills are foundational to success in the workplace for anyone in any career and include competencies such as communications skills, the ability to work on a team, and problem-solving. See Attachment E for an overview of the Common Employability Skills.

Attachment A

IGNITE: Mastering Manufacturing Course Descriptions and Topics

Introduction to Advanced Manufacturing – In this course, learners are introduced to the basic concepts of advanced manufacturing and the many modern technologies used to automate processes. The course uses highly engaging interactive multimedia computer course materials with simulations of the various technologies. The interactive multimedia simulations are combined with hands-on work using real automation equipment to provide an immersive experience.

Topics include: 3D Computer Aided Design (CAD), Robotics programming, CNC programming, electrical control systems, electronic sensors, pneumatics, basic measurement, safety, and materials and processes.

The course consists of 65 hours of instruction and lab experiences.

Advanced Manufacturing Systems 1– In this course, students will learn new skills that build on the technologies covered in the introductory course and combine these technologies into systems. New technology topics will use interactive multimedia computer course materials with simulations and hands-on work with real automation equipment. Students will also work on team projects to design and build working prototype machines that incorporate the various technologies.

New topics include: Programmable Electronic Controllers (PLCs), Flexible Manufacturing/Robotic Systems, Automation Cells, Materials Engineering, Mechanical Systems, Machining, Concepts of Quality, CAD 2, Print Reading 2, Electrical Controls 2, and Safety 2.

The course consists of 130 hours of instruction, lab experiences and team projects.

Advanced Manufacturing Systems 2– In this course, students will learn new skills that build on the technologies covered in the Introductory and Advanced Manufacturing Systems 1 courses and combine these technologies into systems. New technology topics will use interactive multimedia computer course materials with simulations and hands-on work with real automation equipment. Learners will also work on team projects to design and build working prototype machines that incorporate the various technologies.

New topics include: Mechatronics Systems, Lean Manufacturing, Hydraulics, CAD/CAM, CAD 3 and 4, Materials Engineering 2, Plastics Injection Molding, Mold Design, and Welding Concepts.

The course consists of 130 hours of instruction, lab experiences and team projects.

INTRODUCTION TO ADVANCED MANUFACTURING

1 Semester Course

Full learning outcomes list available at www.LIFT.Technology/IGNITE

TOPIC: INTRODUCTION TO ADVANCED MANUFACTURING

LESSON 1	PRINCIPLES OF ADVANCED MANUFACTURING 1
LESSON 2	MANUFACTURING MATERIALS
LESSON 3	PRINCIPLES OF MANUFACTURING PROCESSES

TOPIC: SAFETY 1

LESSON 4	MACHINE SAFETY
LESSON 5	SAFETY RESPONSIBILITIES
LESSON 6	PRACTICING SAFETY IN THE WORKPLACE

TOPIC: PRINT READING

LESSON 7	INTRODUCTION TO PRINT READING
LESSON 8	MULTIVIEW DRAWINGS

TOPIC: MECHANICAL DRIVES 1

LESSON 9	MECHANICAL POWER (WITH VIRTUAL TRAINER)
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TOPIC: BASIC MEASUREMENT

LESSON 10	DIMENSIONAL MEASUREMENT (WITH VIRTUAL TRAINER)
LESSON 11	MEASUREMENT CONVERSION

TOPIC: PRECISION MEASUREMENT 1

LESSON 12	CALIPER MEASUREMENT (WITH VIRTUAL TRAINER)
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TOPIC: AC/DC ELECTRICITY 1

LESSON 13	BASIC ELECTRICAL CIRCUITS (WITH VIRTUAL TRAINER)
LESSON 14	ELECTRICAL CURRENT AND VOLTAGE MEASUREMENTS (WITH VIRTUAL TRAINER)
LESSON 15	ELECTRICAL RESISTANCE MEASUREMENTS (WITH VIRTUAL TRAINER)

TOPIC: FLUID POWER SYSTEMS

LESSON 16	INTRODUCTION TO FLUID POWER (WITH VIRTUAL TRAINER)
LESSON 17	PNEUMATIC POWER (WITH VIRTUAL TRAINER)
LESSON 18	BASIC CYLINDER CIRCUITS (WITH VIRTUAL TRAINER)

TOPIC: ELECTRICAL CONTROL

LESSON 19	CONTROL LOGIC CIRCUITS (WITH VIRTUAL TRAINER)
LESSON 20	ELECTRICAL CONTROL DIAGRAMS (WITH VIRTUAL TRAINER)
LESSON 21	RELAY CONTROL CIRCUITS (WITH VIRTUAL TRAINER)

TOPIC: HAND TOOLS 1

LESSON 22	HAND TOOLS 1
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TOPIC: SAFETY 2

LESSON 23	TYPES OF PPE
LESSON 24	EQUIPMENT SAFETY
LESSON 25	MATERIAL HANDLING SAFETY

TOPIC: ROBOTICS PROGRAMMING 1

LESSON 26	BASIC ROBOTIC OPERATION
LESSON 27	BASIC ROBOT PROGRAMMING (WITH SIMULATION)

TOPIC: ELECTRONIC SENSORS 1

LESSON 28	INTRODUCTION TO ELECTRONIC SENSORS
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TOPIC: COMPUTER AIDED DESIGN 1

LESSON 29	INTRODUCTION TO SOLID MODELING
LESSON 30	SOLID MODEL CREATION
LESSON 31	EXTRUDED FEATURES

TOPIC: CNC MACHINES 1

LESSON 32	INTRODUCTION TO CNC MACHINING
LESSON 33	CNC WORKSPACE
LESSON 34	CNC PROGRAMMING AND OPERATION (WITH VIRTUAL)

TOPIC: SKILL BOSS MINI PROJECTS

TOPIC: SAFETY SKILLS (SKILL BOSS)

TOPIC: PRODUCTION PROCESSES (SKILL BOSS)

TOPIC: QUALITY SKILLS (SKILL BOSS)

TOPIC: MAINTENANCE AWARENESS (SKILL BOSS)

TOPIC: PRODUCTION PROCESSES (SKILL BOSS)

TOPIC: EMPLOYABILITY SKILLS MATHEMATICS 1

LESSON 1	BASIC MATH TERMS AND CONCEPTS
LESSON 2	WHOLE NUMBERS
LESSON 3	FRACTIONS
LESSON 4	DECIMALS
LESSON 5	PERCENTAGE, AVERAGE, AND RATIO
LESSON 6	BASIC GEOMETRY

EMPLOYABILITY SKILLS COMMUNICATIONS

LESSON 1	INTRODUCTION TO COMMUNICATION
LESSON 2	COMMUNICATION: SENDER
LESSON 3	COMMUNICATION: RECEIVER
LESSON 4	COMMUNICATION: MEDIUM
LESSON 5	COMMUNICATION: FEEDBACK AND NOISE

ADVANCED MANUFACTURING SYSTEMS 1

2-SEMESTER COURSE

Full learning outcomes list available at www.LIFT.Technology/IGNITE

TOPIC: PRINCIPLES OF ADVANCED MANUFACTURING 2

- LESSON 1 MANUFACTURING METRICS
- LESSON 2 ADVANCED MANUFACTURING ORGANIZATION
- LESSON 3 TECHNOLOGY AND ADVANCED MANUFACTURING

TOPIC: PRINT READING 2

- LESSON 4 BLUEPRINT DIMENSIONS AND NOTES
- LESSON 5 TOLERANCING
- LESSON 6 MANUFACTURING DRAWINGS AND SCALES

TOPIC: SAFETY 2

- LESSON 8 HAZARDOUS MATERIALS STANDARDS
- LESSON 9 HAZARDOUS MATERIAL HANDLING AND STORAGE
- LESSON 10 WORK AREA SAFETY
- LESSON 11 ACCIDENT AND EMERGENCY RESPONSE

TOPIC: CNC MACHINES 2

- LESSON 12 CNC PROGRAMMING WITH CIRCULAR INTERPOLATION

TOPIC: PRECISION MEASUREMENT 2

- LESSON 13 MICROMETER MEASUREMENT (with virtual trainer)

TOPIC: MATERIALS ENGINEERING 1

- LESSON 14 MATERIAL QUALITY CONTROL

TOPIC: MATERIALS ENGINEERING 2

- LESSON 15 TENSILE STRENGTH ANALYSIS

TOPIC: ROBOTIC PROGRAMMING 2

LESSON 16 BASIC MATERIAL HANDLING (with simulation)

LESSON 17 FLEXIBLE MANUFACTURING CELLS (with simulation)

TOPIC: MACHINE TOOLS 1

LESSON 18 BAND SAW OPERATION

LESSON 19 INTRODUCTION TO DRILL PRESS

TOPIC: COMPUTER AIDED DESIGN 2

LESSON 20 FILLETS AND CHAMFERS

LESSON 21 PRODUCTION DRAWINGS

TOPIC: ELECTRICAL CONTROL

LESSON 22 AUTOMATION SEQUENCE CIRCUITS (with virtual trainer)

TOPIC: ELECTRONIC SENSORS 2

LESSON 23 ELECTRONIC SENSORS 2

TOPIC: AC/DC ELECTRICITY 2

LESSON 24 POWER IN ELECTRICAL CIRCUITS (with virtual trainer)

TOPIC: ELECTRICAL FABRICATION 1

LESSON 25 ELECTRICAL FABRICATION 1

TOPIC: MECHANICAL DRIVES 2

LESSON 26 BASIC MECHANICAL ELEMENTS (with virtual trainer)

LESSON 27 POWER EFFICIENCY (with virtual trainer)

LESSON 28 MECHANICAL POWER TRANSMISSION

TOPIC: PROGRAMMABLE CONTROLLERS 1

LESSON 29 PROGRAMMABLE CONTROLLER OPERATION (with virtual)

LESSON 30 PLC ETHERNET COMMUNICATION

LESSON 31 BASIC PLC PROGRAM INSTRUCTIONS (with virtual)

TOPIC: PROGRAMMABLE CONTROLLERS 2

LESSON 32 PLC PROJECT DEVELOPMENT (Software)

TOPIC: PROGRAMMABLE CONTROLLERS 3

LESSON 34 PLC TIMER INSTRUCTIONS (with virtual)

LESSON 35 PLC EVENT SEQUENCING 1 (with virtual)

TOPIC: QUALITY 1

LESSON 36 INTRODUCTION TO QUALITY

TOPIC: LEAN MANUFACTURING 1

LESSON 37 INTRODUCTION TO LEAN MANUFACTURING

TOPIC: PRECISION MEASUREMENT 3

LESSON 38 INDICATOR MEASUREMENT

TOPIC: MECHANICAL SYSTEMS 3

LESSON 39 GEAR DRIVES (with virtual trainer)

LESSON 40 BELT DRIVES (with Skill Boss)

LESSON 41 CHAIN DRIVES (with Skill Boss)

TOPIC: SKILL BOSS MINI PROJECTS

(Use in both semesters)

SAFETY SKILLS (SKILL BOSS)

PRODUCTION PROCESSES SKILLS (SKILL BOSS)

QUALITY SKILLS (SKILL BOSS)

MAINTENANCE AWARENESS (SKILL BOSS)

TOPIC: ELECTRICAL FABRICATION 2 (Mini Project)

ELECTRICAL FABRICATION 2

TOPIC: MECHATRONICS SYSTEMS 1 (Mini Project)

PLC EVENT SEQUENCING 2 (with virtual)

PICK AND PLACE FEEDING STATION

TOPIC: EMPLOYABILITY SKILLS TEAMS 1

(Use in both semesters)

LESSON 42 TEAM CONCEPTS

LESSON 43 IDEA GENERATION

TOPIC: EMPLOYABILITY SKILLS TEAMS 2

(Use in both semesters)

LESSON 45 TEAM DEVELOPMENT

LESSON 46 INTERPERSONAL SKILL DEVELOPMENT

LESSON 47 TEAM MEETING PREPARATION

LESSON 48 CONDUCTING TEAM MEETINGS

TOPIC: EMPLOYABILITY SKILLS PRODUCT DESIGN

(Use in both semesters)

LESSON 49 PRODUCT DESIGN CONCEPTS

LESSON 50 PRODUCT RESEARCH

LESSON 51 FLOWCHARTS AND FISHBONE DIAGRAMS

TOPIC: EMPLOYABILITY SKILLS PRESENTATIONS

(Use in both semesters)

LESSON 52 BUSINESS PRESENTATION ELEMENTS

LESSON 53 BUSINESS PRESENTATIONS CREATION

LESSON 54 DESIGN OF VISUAL AIDS

**ADVANCED MANUFACTURING SYSTEMS 2
2-SEMESTER COURSE**

Full learning outcomes list available at www.LIFT.Technology/IGNITE

TOPIC: EMPLOYABILITY SKILLS TEAMS 3

LESSON 1 TEAM PERSONALITY

LESSON 2 DECISION MAKING TECHNIQUES

TOPIC: COMPUTER AIDED DESIGN 3

LESSON 3 INTRODUCTION TO 3D ASSEMBLY

LESSON 4 3D ASSEMBLY STANDARD MATES

LESSON 5 3D ASSEMBLY MATE EDITING

TOPIC: COMPUTER AIDED MANUFACTURING 1

LESSON 6 INTRODUCTION TO CAD/CAM

LESSON 7 CAM CONTOUR TOOLPATH

TOPIC: LEAN MANUFACTURING 2

LESSON 8 WORKPLACE ORGANIZATION

LESSON 9 LEAN PRODUCTION

TOPIC: MATERIALS ENGINEERING 3

LESSON 10 DATA ACQUISITION SYSTEMS

TOPIC: PROGRAMMABLE CONTROLLERS 4

LESSON 11 PLC COUNTER INSTRUCTIONS (with virtual)

TOPIC: MECHATRONICS SYSTEMS 2

LESSON 12 STEPPER MOTOR INDEXING SYSTEMS

TOPIC: MECHATRONICS SYSTEMS 3

LESSON 13 CONVEYOR PARTS DISTRIBUTION

TOPIC: MECHATRONICS SYSTEMS 4

LESSON 14 MULTI-STATION MECHATRONIC COMMUNICATIONS

TOPIC: FLUID POWER 2

LESSON 15 HYDRAULIC POWER (with virtual trainer)

LESSON 16 BASIC HYDRAULIC CYLINDER CIRCUITS (with virtual trainer)

TOPIC: QUALITY 2

LESSON 17 BASIC STATISTICAL CONCEPTS

LESSON 18 INTRODUCTION TO CONTROL CHARTS

TOPIC: COMPUTER AIDED DESIGN 4

LESSON 19 SOLID MODEL REVOLVED FEATURES

LESSON 20 3D ASSEMBLY ADVANCED MATES

TOPIC: FLUID POWER 3

LESSON 21 FLUID POWER SPEED CONTROL (with virtual trainer)

LESSON 22 FLUID FORCE AND FRICTION (with virtual trainer)

TOPIC: PLASTICS 1

LESSON 23 INJECTION MOLDING OPERATION

LESSON 24 INJECTION MOLDING QUALITY

TOPIC: MOLD DESIGN 1

LESSON 25 INJECTION MOLD LAYOUT

LESSON 26 BASIC INJECTION MOLD DESIGN

TOPIC: WELDING 1

LESSON 27 INTRODUCTION TO WELDING

LESSON 28 WELDING OPERATIONS

TOPIC: EMPLOYABILITY SKILLS PRODUCT DESIGN ANALYSIS

LESSON 29 PRODUCT EVALUATION

LESSON 30 CONCURRENT ENGINEERING

Attachment B

IGNITE Equipment

Section 1: Minimum Lab Equipment

Note: The following products are made by Amatrol. Consumables, Furniture, and PCs are not included.

96-ADE1 AC/DC Electrical 1 Learning System (Alternate: 990-ACDC1)
96-ADE2 AC/DC Electrical 2 Learning System
96-ECS1 Electrical Control Systems 1 Learning System (Alternate: 990-ECS1)
96-CT1 Computer Control 1 Learning System (Alternate: 990-PAB82 or Table Top Mechatronics)
96-PNE1 Pneumatics 1 Learning System (Alternate: 990-PNE1)
96-PNE2 Pneumatics 2 Learning System
96-CAD1B Computer Aided Design 1 Learning System 1
96-CAM1 Computer Aided Manufacturing 1 Learning System
96-PLS1 Plastics 1 Learning System
94-DFM1 Mold Design 1 Learning System
96-CNC1D CNC Machines 1 Learning System
96-CNC2D CNC Machines 2 Learning System
96-MP1 Machine Tools 1 Learning System
15707 Manual Machine Tools Station
96-MT1 Materials Technology 1 Learning System
96-MES1 Measurement Tools 1 Learning System (Alternate: 990-MES1)
96-MES2 Measurement Tools 2 Learning System
96-MEC1 Mechanical Systems 1 Learning System
96-ROB1A Robotics 1 Learning System
96-ROB2A Robotics 2 Learning System
96-MPF1 Mechanical Fabrication 1 Learning System
96-ELF1 Electrical Fabrication 1 Learning System
96-PK-MF2 Team Project-Automated Can Crusher (quantity 1 per team)
96-PK-MF3 Team Project-FMS Workcell (quantity 1 per team)
95-MSB1 Skill Boss Automation System

Section 2: Optional Lab Equipment

96-HYD1 Hydraulics 1 Learning System
96-MEC2 Mechanical Systems 2 Learning System (Alternate: 990-ME1)
870-PTAB82 Table Top Mechatronics Control System
87-TMS1 TT Mechatronics Inventory Station
87-TMS2 TT Mechatronics Inspection Station
87-TMS3 TT Mechatronics Distribution Station
94-FMS2 Flexible Manufacturing Systems 2

Attachment C

Materials Science Summary

Welcome

Overview of the Modules

- Introduction to Materials Sciences Shoe Design Challenge with Polymers House Design Challenge with Ceramics Lightweight and Safer Cars: Metals
- Materials Science and Engineering Components Design Cycle
- Activity Guide: Scientific Journal Template
- Activity Guide: Infographic Activity Guide: Career Exploration

Module #1: Introduction to Materials Sciences

- Important Concepts of Polymers
- Activity Guide: Where do polymers come from? Important Concepts of Ceramics
- Activity Guide: What are Ceramics? Important Concepts of Metals Activity Guide: What are Metals?
- Activity Guide: Discovery of Manufactured Objects Presentation of Infographics

Module #2: Shoe Design Challenge with Polymers

- Activity Guide: Discovery of polymer microstructure
- Activity Guide: Polymer Discovery through recycling Automobiles Activity Guide: Polymer Discovery through Textiles
- Activity Guide: Safer Batteries Activity Guide: Sourcing Polymers
- Activity Guide: Quantification of Polymer properties Presentation of Prototype

Module #3: House Design Challenge with Ceramics

- Activity Guide: Discovery of ceramic microstructure Activity Guide: Discovery of Concrete
- Activity Guide: Discovery of Glass
- Activity Guide: How to heat and cool your house with Ceramics
- Activity Guide: Sourcing Ceramics
- Activity Guide: Quantification of Ceramic properties Presentation of prototype

Module #4: Lightweight and Safer Cars

- Activity Guide: Scientific Poster
- Activity Guide: Discovery of metal microstructure Activity Guide: Discovery of metals in cars
- Activity Guide: How to cloak your car: Nanoparticles Activity Guide: Sourcing Metals
- Activity Guide: Quantification of Metal properties Presentation of Scientific Poster

Attachment D

IGNITE Capstone Project Briefs

Design Project Brief

Portable Solar-Electric-Living with Fresh Water Sector Project

Prior to assigning this project, *TEAMS 1 MX54338* and *TEAMS 2 MX54339* should be presented and assigned to the class.

PROBLEM STATEMENT:

The Lighter-Than-Air company is developing a product line for developing countries and disaster relief areas.

Around the world, multiple organizations are involved in efforts to assist developing countries with food, water, and shelter. Many of these organizations respond to natural disasters with the same focus. Importantly, the military's needs are similar when they are working in remote, barren areas. The Lighter-Than-Air company would like to develop a new product line to help these organizations and the military as they prepare food and water. Lighter-Than-Air would also like to provide a source of electrical power in these situations.



Figure 1. Solar Power

The new product line will use the acronym: **S.E.L.F.**, which stands for **Solar-Electric-Living with Fresh water**. The product line will include models that will be able to recharge electronic devices, clean tainted water, and/or provide a means of cooking food.

CHALLENGE:

Work as a team using the engineering design process steps to design and build a solar prototype device that will serve as a method of distilling tainted water to create clean water, and create a method of preparing food. The device should weigh less than 12 kilograms and measure less than 1.5 meters in length so that it is easily transported by hand. Bonus: Packaging the entire product into a duffel bag would be ideal.

Design Project Brief

Autonomous Delivery Service Sector Project

Prior to assigning this project, IGNITE lessons TEAMS 1 MX54338 and TEAMS 2 MX54339 should be presented and assigned to the class.

PROBLEM STATEMENT:

The delivery service company, Delivery-One, needs your team's assistance in developing a fast and accurate autonomous service to deliver product to locations.

Today, ordering is completed online with a single click of a mouse. The most dramatic change in this process is the expectation of product delivery. A growing population expects their purchase to be delivered on time and in less than 2 days.



Figure 1. Delivery Service

CHALLENGE:

Work as a team using the engineering design process steps to design and build a delivery service that will pick-up and deliver packages using a remote-controlled drone. The drone will pick up one or more packages from a distribution center and deliver the packages one at a time to specified locations designated by the instructor. Speed and accuracy is of utmost importance due to the flying time limitations of the drone's battery.

Note: Your instructor may give this challenge to multiple teams so your team can compete with other teams. The instructor may provide a competitive award to the team that delivers the packages in the least amount of time.