

Grade level: 9-12

Course Title: CAD/Robotics

Topic/Concept: Introduction to CAD

Time Allotment: 1 week

Unit Sequence: 1

Major Concepts to be learned:

- Engineering design is a structured problem-solving process
- CAD improves precision, communication, and efficiency
- Technology systems work together to solve real-world problems
- Accurate measurement is essential in engineering design

Expected Skills to be demonstrated:

- Engineering design process
- CAD purpose and applications
- Onshape interface navigation

PA Standards/Anchors:

Eligible Content:

3.4.10.A – Apply the engineering design process
3.6.10.A – Analyze technological systems
3.7.10.B – Apply appropriate instruments and measurement systems

Identify steps of the engineering design process
Explain the purpose and applications of CAD technology
Demonstrate safe and responsible computer lab procedures
Navigate the Onshape interface and cloud workspace
Recognize basic engineering and drafting terminology

Instructional Strategies:

Assessments:

- Teacher-led demonstrations
- Guided software walkthroughs
- Interactive vocabulary activities
- Engineering design discussions
- Small-group exploration activities
- Digital scavenger hunts within Onshape

- CAD terminology quiz
- Interface exploration activity
- Participation and lab procedures check

Major Concepts to be learned:

- Precision sketching is the foundation of accurate 3D models
- Constraints communicate design intent and maintain geometry
- Dimensions define size, location, and relationships
- Mathematical relationships are critical in engineering design

Expected Skills to be demonstrated:

- 2D sketch creation
- Constraints and dimensioning
- Fully defined sketches

PA Standards/Anchors:

3.7.10.A – Use appropriate tools to measure and calculate
3.4.10.B – Analyze mathematical relationships in design

Eligible Content:

Create basic 2D sketches using CAD sketch tools
Apply dimensions and geometric constraints
Distinguish between underdefined and fully defined sketches
Use coordinate systems and reference geometry
Apply mathematical relationships to maintain design intent

Instructional Strategies:

- Guided sketching tutorials
- Teacher modeling demonstrations
- Individual sketching exercises
- Peer review activities
- Measurement and dimensioning practice
- Real-world object sketching

Assessments:

- Constrained sketch assignments
- Precision drawing check
- Sketch accuracy rubric

Grade level: 9-12

Course Title: CAD/Robotics

Topic/Concept: Basic Part Modeling

Time Allotment: 2 weeks

Unit Sequence: 3

Major Concepts to be learned:

- 3D models are created from accurate 2D sketches
- Features define the geometry and structure of parts
- Design choices affect manufacturing processes
- Engineering models represent real-world objects accurately

Expected Skills to be demonstrated:

- Extrude and revolve
- Add/remove material
- Feature-based modeling

PA Standards/Anchors:

Eligible Content:

3.4.10.C – Apply design principles to solve problems
3.6.10.C – Evaluate manufacturing processes

Create solid models using extrude and revolve features
Add and remove material using CAD tools
Interpret technical drawings and dimensions
Explain additive and subtractive modeling concepts
Develop models using feature-based design methods

Instructional Strategies:

Assessments:

- Step-by-step modeling demonstrations
- Guided practice exercises
- Independent modeling assignments
- Technical drawing interpretation activities
- Design replication challenges
- Teacher conferencing and feedback

- 3D part modeling project
- Accuracy rubric
- CAD feature competency check

Grade level: 9-12

Course Title: CAD/Robotics

Topic/Concept: Advanced Part Design

Time Allotment: 1 week

Unit Sequence: 4

Major Concepts to be learned:

- Advanced modeling tools improve efficiency and realism
- Engineers optimize designs for performance and manufacturability
- Repeated features can be automated using CAD tools

Expected Skills to be demonstrated:

- Fillets and chamfers
- Patterns and mirroring
- Multi-feature parts

PA Standards/Anchors:

Eligible Content:

3.4.10.D – Evaluate design solutions
3.6.10.D – Analyze system components

Create advanced features including fillets and chamfers
Apply patterns, mirrors, and reference geometry
Analyze how features impact functionality and manufacturability
Modify and optimize part designs
Compare alternative design solutions

Instructional Strategies:

Assessments:

- Feature demonstration lessons
- Reverse engineering activities
- Guided optimization exercises
- Collaborative troubleshooting
- Design comparison activities
- Peer critique sessions

- Complex part design challenge
- Peer design review
- Feature application rubric

Grade level: 9-12

Course Title: CAD/Robotics

Topic/Concept: Assemblies & Systems

Time Allotment: 2 weeks

Unit Sequence: 5

Major Concepts to be learned:

- Engineering systems consist of interacting components
- Assemblies simulate real-world mechanical motion
- Proper constraints ensure functionality and movement

Expected Skills to be demonstrated:

- Assembly creation
- Mates and motion
- Interference detection

PA Standards/Anchors:

Eligible Content:

3.6.10.A – Analyze technological systems
3.4.10.E – Analyze system relationships
3.5.10.C – Use software to solve problems

Assemble multiple components into functioning systems
Apply mates and constraints to control movement
Identify interference and assembly conflicts

Instructional Strategies:

Assessments:

- Assembly demonstrations
- Guided system-building projects
- Motion simulation activities
- Team-based engineering tasks
- Troubleshooting exercises
- Hands-on mechanism analysis

- Functional assembly project
- Motion demonstration
- Assembly functionality rubric

Grade level: 9-12

Course Title: CAD/Robotics

Topic/Concept: Technical Drawing & Documentation

Time Allotment: 2 weeks

Unit Sequence: 6

Major Concepts to be learned:

- Technical drawings communicate manufacturing information
- Standard drafting practices improve clarity and accuracy
- Engineers use drawings to communicate design intent
- Multiple views fully describe an object

Expected Skills to be demonstrated:

- Orthographic projection
- Dimensioning standards
- Section/detail views

PA Standards/Anchors:

Eligible Content:

3.7.10.C – Produce technical drawings
3.4.10.F – Communicate design solutions

Create orthographic projections and multiview drawings
Apply standard dimensioning practices
Produce section and detail views
Interpret engineering drawing conventions
Communicate technical information accurately

Instructional Strategies:

Assessments:

- Blueprint reading activities
- Teacher-led drawing demonstrations
- Dimensioning practice exercises
- Peer drawing critiques
- Technical print analysis
- Independent documentation projects

- Multi-view drawing project
- Blueprint rubric
- Technical communication evaluation

Grade level: 9-12

Course Title: CAD/Robotics

Topic/Concept: Parametric Design & Variables

Time Allotment: 1 week

Unit Sequence: 7

Major Concepts to be learned:

- Parametric design improves adaptability and efficiency
- Variables and equations automate engineering relationships
- Configurations reduce repetitive modeling tasks
- Design intent allows models to update predictably
- Mathematical relationships are essential in engineering design

Expected Skills to be demonstrated:

- Variables and equations
- Configurations
- Design intent modification

PA Standards/Anchors:

Eligible Content:

3.4.10.B – Apply mathematical relationships
3.5.10.B – Advanced software usage

Create and apply variables within CAD models
Use equations to control dimensions and geometry
Develop multiple configurations of a design
Modify models while maintaining design intent
Analyze efficiency improvements through parametric design

Instructional Strategies:

Assessments:

- Guided variable setup demonstrations
- Design-change simulation activities
- Independent modeling exercises
- Problem-solving challenges
- Collaborative troubleshooting sessions
- Real-world engineering examples

- Parametric model assignment
- Design-change challenge
- Configuration accuracy check

Grade level: 9-12

Course Title: CAD/Robotics

Topic/Concept: Measurement, Testing, & Analysis

Time Allotment: 1 week

Unit Sequence: 8

Major Concepts to be learned:

- Measurement verifies engineering accuracy
- Testing and analysis improve product performance
- Tolerances affect manufacturing and assembly success
- Data-driven decisions improve engineering outcomes
- Accurate measurement is critical to quality control

Expected Skills to be demonstrated:

- Mass properties
- Measurement tools
- Tolerances (intro)

PA Standards/Anchors:

3.7.10.B – Measurement systems
3.4.10.D – Evaluate design effectiveness

Eligible Content:

Use CAD measurement tools to analyze models
Calculate mass properties and dimensions
Apply introductory tolerance concepts
Evaluate design accuracy and functionality
Analyze relationships between measurements and performance

Instructional Strategies:

- Measurement labs
- Guided analysis activities
- Real-world tolerance examples
- CAD inspection exercises
- Data interpretation practice
- Small-group problem solving

Assessments:

- Measurement lab
- Analysis worksheet
- Tolerance evaluation activity

Grade level: 9-12

Course Title: CAD/Robotics

Topic/Concept: Manufacturing & Prototyping

Time Allotment: 1-2 weeks

Unit Sequence: 9

Major Concepts to be learned:

- Manufacturing transforms designs into usable products
- Material selection impacts cost and performance
- Prototyping allows engineers to test and improve designs
- Digital manufacturing improves efficiency and precision

Expected Skills to be demonstrated:

- 3D printing prep (STL export)
- Materials selection
- Intro to CNC concepts

PA Standards/Anchors:

Eligible Content:

3.6.10.C – Manufacturing processes
3.4.10.G – Apply design to real-world problems
3.5.10.A – Technology use

Prepare CAD files for 3D printing
Export STL files for manufacturing
Compare manufacturing methods and materials
Explain introductory CNC machining concepts

Instructional Strategies:

Assessments:

- Additive manufacturing demonstrations
- Prototype evaluation activities
- Material comparison labs
- Manufacturing process discussions
- Project-based learning activities
- Real-world product analysis

- Prototype design project
- Manufacturing plan
- Material selection justification

Grade level: 9-12

Course Title: CAD/Robotics

**Topic/Concept: Collaboration &
Cloud-Based Design**

Time Allotment: 1 week

Unit Sequence: 10

Major Concepts to be learned:

- Modern engineering relies on collaboration and communication
- Cloud-based tools improve workflow efficiency
- Version control protects design integrity
- Engineering teams share responsibilities and ideas

Expected Skills to be demonstrated:

- Sharing and permissions in Onshape
- Version control
- Collaborative workflows

PA Standards/Anchors:

Eligible Content:

3.5.10.D – Communication technology
3.6.10.E – Impacts of technology

Share and manage CAD files using cloud platforms
Apply version control and revision tracking
Collaborate effectively within engineering teams
Analyze the impact of communication technology
Present engineering solutions digitally

Instructional Strategies:

Assessments:

- Team-based CAD projects
- Shared modeling activities
- Peer feedback sessions
- Collaborative problem-solving exercises
- Teacher-facilitated teamwork discussions
- Digital presentation activities

- Team design mini-project
- Revision history check
- Collaboration rubric

Grade level: 9-12

Course Title: CAD/Robotics

Topic/Concept: Design Challenges

Time Allotment: 1-2 weeks

Unit Sequence: 11

Major Concepts to be learned:

- Engineering design is iterative and solution-focused
- Constraints guide engineering decisions
- Innovation requires testing, feedback, and revision
- Systems thinking improves design effectiveness

Expected Skills to be demonstrated:

- Open-ended problem solving
- Iteration and redesign
- Constraints-based design

PA Standards/Anchors:

Eligible Content:

3.4.10.A–G – Full design process
3.6.10.A–E – Systems thinking

Apply the engineering design process to open-ended problems
Analyze constraints and criteria in engineering design
Develop and revise prototype solutions
Evaluate system performance and efficiency
Document iterative improvements and redesigns

Instructional Strategies:

Assessments:

- Challenge-based learning
- Team engineering competitions
- Brainstorming sessions
- Prototype testing and redesign
- Reflection and design journals
- Teacher conferencing and feedback

- Design challenge rubric
- Reflection journal
- Prototype evaluation

Grade level: 9-12

Course Title: CAD/Robotics

Topic/Concept: Capstone Project

Time Allotment: 2-3 weeks

Unit Sequence: 12

Major Concepts to be learned:

- Engineering integrates creativity, problem-solving, and technical skills
- Effective design requires planning, testing, and communication
- Engineers use technical documentation to communicate solutions
- Design projects must balance function, aesthetics, and manufacturability
- Professional presentations communicate engineering ideas effectively

Expected Skills to be demonstrated:

- Problem identification
- Full CAD workflow
- Presentation and justification

PA Standards/Anchors:

Eligible Content:

3.4.10.A–G – Engineering design
3.5.10.A–D – Technology use
3.6.10.A–E – Systems

Identify and define engineering problems
Apply the full engineering design process independently
Create complete CAD models and technical drawings
Present and justify design decisions
Demonstrate mastery of CAD software and engineering communication

Instructional Strategies:

Assessments:

- Independent project-based learning
- Teacher mentoring and conferencing
- Design reviews and critiques
- Research and development activities
- Presentation practice sessions
- Peer collaboration and feedback

- Final project (model + drawings)
- Presentation
- Rubric-based evaluation
- Engineering design portfolio

Grade level: 9-12

Course Title: CAD/Robotics

**Topic/Concept: Introduction to Robotics
Systems & Collaborative Problem Solving**

Time Allotment: 4 weeks

Unit Sequence: 13

Major Concepts to be learned:

- Robotics safety and laboratory procedures
- Introduction to VEX EXP components and systems
- Drivetrain construction and mechanical assembly
- Basic coding structures and autonomous movement
- Team communication and strategic gameplay

Expected Skills to be demonstrated:

- Identify and properly use VEX EXP components
- Program autonomous and driver-controlled movement
- Demonstrate effective teamwork and communication
- Modify robot behavior using trial-and-error testing
- Record and analyze performance data

Construct and troubleshoot a basic drivetrain robot
Apply problem-solving strategies during gameplay

PA Standards/Anchors:

Eligible Content:

3.4.10.A – Apply knowledge of technological systems
3.4.10.C – Assess the impacts of technological systems
3.6.10.A – Analyze engineering design processes
3.6.10.C – Apply the engineering design process
3.7.10.B – Apply appropriate instruments and apparatus
CC.2.2.HS.D.1 – Reason quantitatively and use units

Apply safe operating procedures in a laboratory environment
Identify robotic subsystems and component functions
Construct mechanical systems using technical instructions
Program robotic movement using sequencing and control structures
Evaluate design effectiveness through testing and redesign
Collect and interpret performance data
Demonstrate collaboration in engineering tasks

Instructional Strategies:

Assessments:

- Teacher demonstrations and guided practice
- Cooperative learning teams
- Robotics build tutorials
- Engineering design journals
- Small-group troubleshooting sessions
- Coding simulations and testing activities
- Competitive gameplay scenarios
- Reflection discussions after challenges

- Safety quizzes
- Build checkpoints
- Coding practice activities
- Team participation observations
- Engineering notebook reviews

Grade level: 9-12

Course Title: CAD/Robotics

Topic/Concept: Precision Control, Team Strategy, & Applied Robotics Competition

Time Allotment: 4-5 weeks

Unit Sequence: 14

Major Concepts to be learned:

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| <ul style="list-style-type: none">• Precision driving and maneuverability• Game strategy and tactical planning• Sensor integration for navigation• Data collection and performance analysis• Collaboration in competitive engineering environments | <ul style="list-style-type: none">• Remote control systems and driver skills• Robot stability and mechanical efficiency |
|--|--|

Expected Skills to be demonstrated:

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|--|--|
| <ul style="list-style-type: none">• Build and optimize a competition-ready robot• Apply strategic thinking during gameplay• Analyze robot strengths and weaknesses• Work collaboratively in team-based competitions | <ul style="list-style-type: none">• Demonstrate advanced driving control techniques• Use sensors to improve robot performance• Adjust robot design based on testing feedback |
|--|--|

PA Standards/Anchors:

Eligible Content:

3.4.10.B – Apply concepts of mathematics and science in technology
3.4.10.D – Evaluate the effectiveness of technological solutions
3.6.10.B – Analyze systems, subsystems, and controls
3.6.10.C – Evaluate engineering solutions
3.7.10.C – Use appropriate technology and resources
CC.2.2.HS.D.2 – Use algebraic reasoning in problem solving
CC.3.5.9-10.B – Cite evidence to support analysis

Apply mathematical reasoning to robotic movement and speed
Design robotic systems for precision tasks
Evaluate drivetrain efficiency and control
Program and refine driver-controlled systems
Analyze competitive outcomes using collected data
Implement revisions through iterative testing
Demonstrate teamwork and leadership skills

Instructional Strategies:

Assessments:

- | | |
|--|--|
| <ul style="list-style-type: none">• Competitive robotics scrimmages• Strategy planning sessions• Peer coaching and driver practice• Video analysis of robot performance• Sensor integration demonstrations• Design modification workshops• Collaborative engineering discussions• Data tracking and analysis activities | <ul style="list-style-type: none">• Driver skill evaluations• Sensor programming checkpoints• Design review discussions• Peer collaboration rubrics• Practice match observations |
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Grade level: 9-12

Course Title: CAD/Robotics

Topic/Concept: Structural Design, Obstacle Navigation, & Engineering Optimization

Time Allotment: 4-5 weeks

Unit Sequence: 15

Major Concepts to be learned:

- Mechanical advantage and gearing
- Obstacle negotiation techniques
- Iterative testing and redesign
- Autonomous and driver-assisted navigation

Structural stability and durability
Center of gravity and balance
Engineering constraints and trade-offs

Expected Skills to be demonstrated:

- Design robots capable of overcoming physical obstacles
- Construct and test geared mechanical systems
- Program controlled movement for obstacle navigation
- Collaborate to improve robot performance

Apply concepts of balance and stability in design
Analyze and improve robot efficiency
Use engineering documentation practices

PA Standards/Anchors:

Eligible Content:

3.4.10.A – Analyze technological systems and subsystems
3.4.10.B – Apply scientific and mathematical concepts
3.6.10.A – Apply engineering design concepts
3.6.10.D – Evaluate design constraints and impacts
3.7.10.A – Apply advanced tools and technologies
CC.2.3.HS.A.3 – Apply geometry concepts to modeling situations
CC.3.5.9-10.C – Follow technical procedures precisely

Analyze robot structural integrity and performance
Apply gearing concepts to increase torque or speed
Evaluate obstacle navigation solutions
Construct and revise robotic systems based on testing
Apply geometry and measurement concepts to robotics
Demonstrate effective use of engineering design documentation
Collaborate in solving technical design challenges

Instructional Strategies:

Assessments:

- Hands-on build challenges
- Obstacle course testing sessions
- Guided experimentation with gears and wheels
- Teacher-led engineering demonstrations
- Design comparison activities
- Group troubleshooting discussions
- CAD or sketch-based design planning
- Reflection and redesign conferences

- Gear ratio practice activities
- Obstacle navigation trials
- Design sketches and planning sheets
- Engineering notebook checkpoints
- Team collaboration observations

Grade level: 9-12

Course Title: CAD/Robotics

**Topic/Concept: Automated Systems,
Precision Placement, & Engineering Innovation**

Time Allotment: 4-5 weeks

Unit Sequence: 16

Major Concepts to be learned:

- Automated robotic systems
- Arm and lift mechanisms
- Engineering optimization and efficiency
- Competitive robotics problem solving

Precision movement and object manipulation
Sensor feedback and control systems
Advanced programming logic

Expected Skills to be demonstrated:

- Design and construct robotic lifting and placement systems
- Integrate sensors for automated control
- Troubleshoot mechanical and coding problems
- Demonstrate leadership and collaboration skills

Program robots for accurate object manipulation
Analyze efficiency and precision in robotic tasks
Apply iterative redesign strategies

PA Standards/Anchors:

Eligible Content:

3.4.10.C – Evaluate technological solutions and impacts
3.5.10.B – Apply advanced computer and software concepts
3.6.10.B – Analyze engineering systems and controls
3.6.10.C – Evaluate engineering designs and prototypes
3.7.10.D – Utilize technological resources effectively
CC.2.1.HS.F.1 – Apply numerical reasoning in measurement and precision
CC.3.6.9-10.F – Produce clear technical writing

Construct robotic systems for lifting and placement tasks
Program autonomous routines using sensors and logic structures
Analyze precision and consistency in robotic performance
Troubleshoot programming and mechanical failures
Apply engineering redesign based on testing data
Document technical processes and design changes
Demonstrate teamwork and project management skills

Instructional Strategies:

Assessments:

- Advanced coding workshops
- Lift and arm mechanism demonstrations
- Collaborative engineering design sessions
- Precision testing activities
- Sensor calibration labs
- Team-based robotics competitions
- Performance data analysis
- Engineering notebook reflections

- Programming logic exercises
- Lift mechanism build checks
- Sensor calibration activities
- Team planning meetings
- Performance testing logs