

# ROBOTICS: URBAN SEARCH AND RESCUE



## PURPOSE

To evaluate each contestant's preparation for employment and to recognize outstanding students for excellence and professionalism in the field of robotics.

First, download and review the General Regulations at: <http://updates.skillsusa.org>.

## ELIGIBILITY (TEAM OF 2)

Open to active SkillsUSA members enrolled in programs with robotics, engineering, automation, manufacturing, electronics, and emergency services as the occupational objectives.

## CLOTHING REQUIREMENTS

### Class E: Contest specific — Business Casual

- Official SkillsUSA white polo shirt
- Black dress slacks (accompanied by black dress socks or black or skin-tone seamless hose) or black dress skirt (knee-length, accompanied by black or skin-tone seamless hose)
- Black leather closed-toe dress shoes

These regulations refer to clothing items that are pictured and described at:

[www.skillsusastore.org](http://www.skillsusastore.org). If you have questions about clothing or other logo items, call 800-401-1560 or 703-956-3723.

**Note:** Contestants must wear their official contest clothing to the contest orientation meeting.

## EQUIPMENT AND MATERIALS

1. Supplied by technical committee:
  - a. Challenge field: 12' x 12' simulated neighborhood
  - b. Field elements: components of a residential area and obstacles to traverse, open, and manipulate in order

- c. to locate and dispose of simulated explosive ordnances
- c. A command center area equipped with a table, two chairs, and a video monitor
- d. General workspace for each team designated as a "pit" area, including one table, two chairs, and access to a 120-volt electrical supply
2. Supplied by the contestant:
  - a. Safety equipment — eye protection is required at all times in the contest area
  - b. Laptop computer (optional) for technical presentation purposes only. Laptop not used for robot operation.
  - c. Fully assembled, tested, and operational ordnance disposal robot conforming to the guidelines and parts restrictions listed in this document (see "Urban Search and Rescue Challenge Kit Bill of Materials" in Appendix)
  - d. Team number affixed to robot
  - e. Presentation software for oral presentation to judges (optional)
  - f. CAD/CAM software for blueprint design (optional)
  - g. Completed Engineering Notebook  
**Note:** Technical drawing/blueprint of robot drive chassis must be included in notebook
  - h. Pens, pencils and paper
  - i. Tools:
    1. Allen wrench set (English)
    2. Clamping vise
    3. Metal tin snips
    4. Power strip
    5. Calculator
    6. Tape measure
    7. Hammer
    8. Metal file
    9. Flat-head and Phillips-head screwdrivers
    10. Wire strippers (one set)
    11. Wire cutters/snips (one set)
    12. Roll of electrical tape
    13. 4" nylon wire ties (25 pack)
    14. Multimeter
    15. Multinut pliers
    16. Metal-cutting hacksaw (manual)
    17. Cordless drill with charger
    18. Set of standard drill bits
    19. Pliers (needle nose or regular)
    20. Set of box wrenches
  - j. All competitors must create a one-page résumé and submit a hard copy to the

technical committee chair at orientation. Failure to do so will result in a 10-point penalty.

**Note:** Your contest may also require a hard copy of your résumé as part of the actual contest. Check the Contest Guidelines and/or the updates page on the SkillsUSA website at <http://updates.skillsusa.org>.

## SCOPE OF THE CONTEST

### Knowledge Performance

This portion of the contest will entail a knowledge exam. Competencies evaluated on the written portion will be general principles used in robotics. There will be a 30-minute limit for the written test.

### Skill Performance

A two-member team builds its robot and arm mechanism prior to the competition and then, during the competition, remotely operates the robot, which should be capable of locating, grabbing and moving simulated ordnances on the challenge course. This remotely operated vehicle (ROV) must traverse the course, locate the ordnances, secure them and properly dispose of them. Each team will perform one round of competition consisting of a time-limited mission to locate and dispose of two ordnances.

### Contest Guidelines

1. Teams must be comprised of two students. If a team member is absent, the lone team member will be allowed to compete, but a 30-point penalty will be applied to the overall score.
2. Each robot must have an identification label with the team's number listed.
3. Each technical presentation should last for 12 minutes and should be primarily oral, with supporting materials of printed or electronic media and physical models. Penalty for presentation over/under 12 minutes will be assessed. Students should be prepared to discuss the roles they played, their robot design, and the functions of their robot. (**Note:** The technical committee will not provide projector, screen or other presentation equipment.)
4. Team members should design, build, and experiment with robots constructed for the SkillsUSA Urban Search and Rescue Challenge. Other approved parts and raw materials may also be used. The prebuilt robot and arm mechanism will be required to grab, hold and move objects during the mission.
5. The robot's arm mechanism must be capable of opening a standard-size mailbox and reaching *into the box up to five inches*, grabbing the simulated ordnance and pulling it out of the mailbox. The arm mechanism must be capable of reaching items positioned *up to nine inches above the floor*.
6. Part Restrictions:
  - a. Limit of four continuous rotation DC motors or servo motors per competing robot
  - b. Limit of four standard-scale proportional servo motors or equivalent
  - c. Maximum of one transmitter (up to six channels)
  - d. Maximum of two DC motor controllers
  - e. One rechargeable battery pack for drivetrain motor power, maximum 12V
  - f. One battery pack for receiver and/or servo power, maximum 6V
  - g. One battery operated wireless camera, maximum 9V. This single camera must be mounted to the robot
  - h. Robot must fit into an 18" x 18" x 18" space when starting but may be expanded to a larger size during the challenge.
  - i. Any other battery-operated components installed on the robot must use one of the above-listed power sources
  - j. Each team must provide in its engineering notebook a technical drawing or blueprint detailing the construction of its robot drive chassis and additional drawings/blueprints for its associated arm mechanism.
  - k. The robot and arm mechanism must be assembled by the team prior to the competition.
  - l. All robots will be required to pass inspection by judges to determine if all of the parts used are from the list of allowed parts.
  - m. Robots will not be allowed to compete with an arm mechanism that poses

- danger to competitors or could potentially cause damage to the challenge field.
- n. Accuracy of the robot's construction matching the blueprint will be considered during scoring. All necessary parts and tools for construction must be brought to the competition site.
  - o. Team members will be required to follow proper safety procedures and use eye protection at all times in the contest area.
  - p. Teams may bring a laptop computer and blueprint drawings of their robot and arm mechanism designs to the contest building area. A description of the assembly process is required to be within the Engineering Notebook. The designs also may be printed or hand-drawn copies.

### Engineering Notebook

The Engineering Notebook will be submitted for judging at check-in. Required elements include:

1. Overall neat and professional appearance
2. A complete bill of materials for the robot drive chassis and arm mechanism designed and used in competition at the event
3. A detailed description of the assembly process for the robot drive chassis and arm mechanism
4. Illustrations, sketches, photos, and written log entries accurately documenting the design and prototyping iterations detailing the evolution and logical progression of the robot's design
5. Explanations noting how testing was conducted, why modifications were made, skills learned, and how robot might further be modified to improve performance and achieve desired objectives if no restrictions were in place

### Challenge Course Rules

**Note:** Team members must wear safety glasses at all times while they are in the competition area! All teams will be expected to adhere to the official rules for the Urban Search and Rescue Challenge competition and compete in a positive and professional manner.

1. A time trial must be completed prior to the timed mission. The ordnance will be placed in a specified location on the course and the route traveled to retrieve and dispose of the ordnance must be identical for all teams. This route will be determined by the event chairperson.
2. At the competition site, the simulated residential area will be provided and maintained by the technical committee. During competition, the course will be reset to its original state before each team competes. The ordnance pieces will be placed before each team competes.
3. The Urban Search and Rescue Challenge event will consist of a time trial and a single timed mission for each team. During the mission, the robot has up to six minutes to navigate the course, complete the challenge and return to home base.
4. Each team will operate its mobile robot and navigate by line of sight and by the video feed from an onboard wireless camera. The command center will be within view of the playing field, and team members must remain seated at the command center while competing.
5. An official will be in charge of placing the team's robot at the starting point on the challenge course. (Reminder: The robot must fit within an 18" x 18" x 18" space at the start but may expand to any size after it enters the neighborhood.)
6. After a "clear" signal is issued by a challenge course official, time will begin as soon as the robot moves. Following completion of a mission, time will stop upon successful return to home base following disposal of two simulated explosive ordnances or expiration of the six-minute time limit.
7. Robots should remain on roads and paths within the neighborhood to avoid property damage. Shortcuts are not allowed and will result in penalties.
8. The mission will last a maximum of six minutes.
9. Team members are not allowed to touch their robot at any time while a mission is in progress, unless instructed to do so by a judge.
10. The containment unit where the ordnance pieces are placed by the robot

after removal from the course must remain outside the field of play and as close to the starting position as possible. Any team that deliberately moves the containment unit from its starting point will be penalized.

11. An official will award points for the team's mission based on the official contest rubric.

### Penalties

1. A deduction will be assessed each time an ordnance is dropped.
2. Each time the robot stalls or becomes hung up and has to be freed by officials, a deduction will be assessed. An official will free a robot at the request of a team member.
3. A deduction will be assessed whenever a robot goes off the designated path within the neighborhood or outside of the course boundaries. Shortcuts are not allowed.

### Approved Materials

Approved robot materials and quantity to be used:

#### Urban Search and Rescue Challenge Bill of Materials

4" wheel	6
16T sprocket	4
24T Sprocket	6
32T Sprocket	2
Chain w/Link	1
Chain Breaker	1
Gear Hub Spacer	10
100 mm Axle	12
DC Drive Motor	2
Motor Mount	2
Axle Set Collar	12
288 mm Channel	6
160 mm Channel	4
96 mm Channel	4
32 mm Channel	6
L Bracket	6
Flat Building Plate	2
Flat Bracket	6
2" Standoff Post	12
1" Standoff Post	12
180 Servo	2
Single Servo Bracket	2
180 Servo Bronze Bushing	24
Axle Hub	12

Motor Hub	2
1/8" Axle Spacer	24
3/8" Axle Spacer	6
Motor Power Cable	2
On/Off Switch	1
12-volt Battery	1
Motor Speed Controller	1
1/2 SHCS	200
Hex Keys	1
Zip Tie Pack	20
Kep Nut	200
3/8" BHCS	50
NiMH Battery Charger	1
4ch R/C Controller	1
288 mm Flat Bar	4
Servo Pivot w/Bearing	1
80T Gear	2
40T Gear	2
Electronics Deck	1
Green Bin	1
Lid	1
Top Card	1
Side Label Sticker	1

#### Camera Pack

900 MHz Camera	1
9-volt Adaptor	1
Camera Mount	1

#### Control System

2.4 GHz 6ch R/C Controller	1
----------------------------	---

#### Additional parts and raw materials legal for use:

1. Other robot parts similar in size and design to Urban Search and Rescue Challenge materials
2. One 12" x 24" sheet of acrylic plastic, maximum thickness of 0.250"
3. One 12" x 24" sheet of aluminum, maximum thickness of .080"
4. 3-D-printed parts of original design
5. Raw material used for fabricating custom robot part

### Standards and Competencies

#### RR 1.0 — Demonstrate knowledge in safety rules and practices

- 1.1 Maintain a safe work area
- 1.2 Demonstrate safe and correct use of hand tools

- 1.3 Follow safety rules during robotic assembly
- 1.4 Demonstrate safe operation of robotic equipment in teleop mode

**RR 2.0 – Produce technical documentation**

- 2.1 Keep an engineering notebook detailing design discussions, design details, design changes and troubleshooting notes
- 2.2 Develop a technical drawing of the final competitive robot design
- 2.3 Produce a bill of materials for the final competitive robot design
- 2.4 Explain design choices and changes made within the engineering design process

**RR 3.0 – Demonstrate knowledge of robot parts**

- 3.1 Identify mechanical and electrical parts of the final robot design
- 3.2 Demonstrate understanding of the mechanical and electrical functions of the parts of the final robot design

**RR 4.0 – Demonstrate understanding of robot mechanical systems**

- 4.1 Identify mechanical systems within the final robot design
- 4.2 Demonstrate the function of control systems of the final robot design
- 4.3 Demonstrate and explain the functioning of the drive train of the robot
- 4.4 Demonstrate and explain the functioning of the package delivery system of the robot

**RR 5.0 – Demonstrate understanding of robot electrical systems**

- 5.1 Identify electrical/electronic systems within the final robot design
- 5.2 Demonstrate and explain the function of electrical control systems of the final robot design

**RR 6.0 – Demonstrate teleop [S11] skills and real-time problem solving**

- 6.1 Demonstrate ability to safely and quickly maneuver the robot through rough and unknown terrain via teleop
- 6.2 Demonstrate ability to overcome challenging areas of course terrain via teleop

- 6.3 Demonstrate ability to locate objects through remote robotic manipulation via teleop
- 6.4 Demonstrate ability to transport objects via teleop

**RR 7.0 – Demonstrate ability to present and explain technical information**

- 7.1 Demonstrate correct and effective use of oral, written and technological tools to present technical information regarding engineering design process, robot construction and robotic teleop control
- 7.2 Demonstrate knowledge of design choices and implementations during the engineering design process
- 7.3 Demonstrate knowledge of team processes and individual team member contributions

**Committee Identified Academic Skills**

The technical committee has identified that the following academic skills are embedded in this contest.

**Math Skills**

- Use scientific notation
- Use fractions in contextual applications to solve problems
- Students use percentages in contextual applications to solve problems.
- Students solve problems through the contextual application of proportions.
- Students measure time, distance, and angles within contextual problem-solving applications.
- Students simplify numeric expressions.
- Students use comparisons, predictions, and inferences in analyzing data to solve a problem.
- Students use modeling techniques to solve problems.
- Students write and solve algebraic expressions in one or more variables.
- Students use derived measurements to solve problems.

**Science Skills**

- Plan and conduct a scientific investigation
- Apply knowledge of heat, sound, mechanical, chemical, electrical and light

energy within contextual problem-solving applications

- Apply knowledge of kinetic and potential energy in contextual applications to solve problems
- Use knowledge of Newton's laws of motion
- Use knowledge of simple and compound machines to solve problems
- Apply knowledge of gears, motors and linkages to solve problems within contextual applications
- Use formulas to solve problems
- Apply scientific knowledge within the engineering design process
- Apply knowledge of force and motion concepts in contextual problem solving
- Use knowledge of mechanical, chemical and electrical energy
- Use knowledge of temperature scales, heat and heat transfer
- Use knowledge of work, force, mechanical advantage, efficiency and power
- Use knowledge of principles of electricity and magnetism
- Use knowledge of static electricity, current electricity and circuits
- Use knowledge of signal frequencies and baud rate
- Use knowledge of communication modes (full/half duplex)

### Engineering Skills

- Apply the engineering design process to solve a contextual problem
- Apply the principles of circuit analysis
- Apply the elements of circuit design and construction
- Understand and apply energy and power types, sources, and conversions
- Apply methods of maintaining, servicing, troubleshooting and repairing systems
- Apply skills and techniques related to building, repairing, and maintaining robotic mechanisms
- Apply techniques and technologies related to the production of technical drawings
- Apply basic mechanical skills related to robotic design, construction, and troubleshooting
- Understand and apply knowledge of safety during construction and use of equipment

- Apply problem-solving and engineering-design processes to solve unforeseen challenges

### Language Arts Skills

- Make effective use of spoken, written, and visual communications with team members within the problem-solving and engineering-design processes
- Make effective use of spoken, written, and visual communications with a variety of audiences
- Use appropriate information resources within the research-and-design process
- Organize and synthesize information for use in research-and-design processes and in written and oral presentations
- Demonstrate the ability to correctly read and interpret rules, instructions, and specifications within the robotic challenge
- Demonstrate the proper use of language, both written and verbal
- Demonstrate knowledge of appropriate reference materials

### Connections to National Standards

State-level academic curriculum specialists identified the following connections to national academic standards.

#### Math Standards

- Algebra
- Data analysis and probability
- Problem solving
- Reasoning and proof
- Communication
- Connections
- Representation

**Source:** NCTM Principles and Standards for School Mathematics. For more information, visit: <http://www.nctm.org>.

#### Science Standards

- Understands relationships among organisms and their physical environment
- Understands the sources and properties of energy
- Understands forces and motion
- Understands the nature of scientific inquiry

**Source:** McREL compendium of national science standards. To view and search the compendium, visit: <http://www2.mcrel.org/compendium/browse.asp>.

### **Language Arts Standards**

- Students apply a wide range of strategies to comprehend, interpret, evaluate and appreciate texts. They draw on their prior experience, their interactions with other readers and writers, their knowledge of word meaning and of other texts, their word identification strategies and their understanding of textual features (e.g., sound-letter correspondence, sentence structure, context, and graphics)
- Students adjust their use of spoken, written and visual language (e.g., conventions, style, vocabulary) to communicate effectively with a variety of audiences and for different purposes
- Students use spoken, written and visual language to accomplish their own purposes (e.g., for learning, enjoyment, persuasion and the exchange of information)

**Source:** IRA/NCTE Standards for the English Language Arts. To view the standards, visit: [www.ncte.org/standards](http://www.ncte.org/standards).