



ROBOTICS — URBAN SEARCH AND RESCUE



SkillsUSA Championships Technical Standards

PURPOSE

To evaluate each competitor'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 updates.skillsusa.org.

ELIGIBILITY (TEAM OF TWO)

Open to a team of two (2) active SkillsUSA members from the same local chapter (school) enrolled in programs with robotics, engineering, automation, manufacturing, electronics, and emergency services as an occupational objective. Each state may send one middle school, one high school, and one college/postsecondary team. A full team must be registered. See General Regulations for more information about substitution and penalty rules.

CLOTHING REQUIREMENTS

Class E: Competition Specific — Business Casual

- Official SkillsUSA white polo shirt
- Black dress slacks or black dress skirt (knee-length minimum)
- Black closed-toe dress shoes

Note: Wearing socks or hose is not required. If worn, socks must be black dress socks and hose must be either black or skin-tone and seamless/nonpattern.

Note: Safety glasses must have side shields or goggles. (Prescription safety glasses may be used only if they are equipped with side shields. If not, they must be covered with goggles.)

These regulations refer to SkillsUSA Championships Clothing Classifications that are pictured and described at skillsusastore.org. If you have questions about competition uniforms, call the SkillsUSA Store at 888-501-2183.

Note: Competitors must wear their official competition clothing to the competition orientation.

EQUIPMENT AND MATERIALS

1. Supplied by technical committee:
 - a. Challenge field: 30' by 40' simulated neighborhood
 - b. Field elements: components of a residential area and obstacles to traverse, open, and manipulate to locate and dispose of simulated explosive ordnances
 - c. A command center area equipped with a table, a driver chair, spotter area, video monitor, and two-way communication equipment for driver and spotter.
 - d. General workspace for each team designated as a “pit” area, including one table, two chairs, and access to power
2. Supplied by the competitor:
 - a. Safety equipment — eye protection is always required in the competition 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” below
 - 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. One 6' multiple-outlet surge protector
 - j. 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). Multi-nut 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
- 21). All competitors must create and submit online a one-page single sided resume.
See “Online Submission Requirements” below for guidelines.

Note: All national competitors must also check for competition-specific updates and/or competitor preparation instructions on the SkillsUSA website at updates.skillsusa.org.

PROHIBITED DEVICES

Cellphones, electronic watches and/or other electronic devices not approved by a competition’s national technical committee are **NOT** allowed in the competition area. Please follow the guidelines in each technical standard for approved exceptions. Technical committee members may also approve exceptions onsite during the SkillsUSA Championships if deemed appropriate.

Penalties for Prohibited Devices

If a competitor’s electronic device makes noise or if the competitor is seen using it at any time during the competition, an official report will be documented for review by the Director of the SkillsUSA Championships. If confirmed that the competitor used the device in a manner which compromised the integrity of the competition, the competitor’s scores may be removed.

ONLINE SUBMISSION REQUIREMENTS

All SkillsUSA national competitors must submit their one-page single sided resume online. The deadline and link for online submissions will be published on updates.skillsusa.org. Failure to submit any of the required document(s) listed below by the established deadline will result in a 10-point penalty.

1. One-page single sided resume

Your submission must be saved as PDF file type using the file name format of “Your Last Name_Your First Name_Resume.” For example, “Amanda Smith” would save the individual PDF submissions file as:

- Smith_Amanda_Resume

SCOPE OF THE COMPETITION

KNOWLEDGE PERFORMANCE

The competition will include a test assessing knowledge of general principles used in robotics. There will be a 30-minute time limit for completing the test. Competitors are also required to take the SkillsUSA Professional Development Test.

SKILL PERFORMANCE

A two-member team builds its robot and arm mechanism prior to the competition and then, during the competition, there will be two (2) separate but related challenges. The first will be a demonstration of proficiency in five (5) specific skill trials. The second is a simulated urban

search and rescue mission to traverse a course and locate, secure, and properly dispose of ordnances. Both challenges will require teams to demonstrate proficiencies, such as remotely operating the robot via camera, navigation, manipulating the arm mechanism to collect simulated ordnances, traversing various types of terrain, and communication between driver and spotter. Each team will perform one round of the five (5) skill trials and one round of the simulated mission to locate and dispose of two ordnances. In both challenges, teams will be under time constraints to complete the objective.

COMPETITION GUIDELINES

1. Each robot must have an identification label with the team's number listed.
2. Each technical presentation should last for a maximum of five (5) minutes and should be primarily oral, with supporting materials from printed or electronic media and physical models. After five minutes, the competition staff will call for the presentation to end with no penalty assessed to the team score for exceeding the five-minute maximum. Competitors should be prepared to answer questions from the judges after the presentation is complete. 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.)
3. Team members should design, build, and experiment with robots constructed from the list of approved parts for the SkillsUSA Robotics: Urban Search & Rescue Challenge. The prebuilt robot and arm mechanism will be required to grab, hold, and move objects during associated skills challenges and during the main challenge.
4. 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*.
5. Part Restrictions:
 - a. Limit of eight (8) total motors in any combination of DC, and/or servo-type motors.
 - b. Implementation of pneumatic systems is prohibited due to safety concerns of potential rupture of onboard pressure vessels used to power pneumatics on a mobile robot in an unprotected arena.
 - c. Maximum of one remote control transmitting system.
 - d. One rechargeable battery pack to power the robot's mechanical functions. Maximum voltage should not exceed manufacturing specs of 12.8V. Other energy storage devices are not allowed, e.g., capacitors.
 - e. One battery-operated wireless camera must be mounted to the robot. A supplemental battery to power camera can be used and cannot exceed a maximum of 9V.
 - f. Robot battery pack must be securely fastened to the robot's chassis away from sharp edges, corners, screws, and moving parts.
Note: See penalties section for rules about batteries that become detached during competition runs.
 - g. Robot must fit into an 18" by 18" by 18" space for robot inspection but may be expanded to a larger size during the challenge.

- h. Any other battery-operated components installed on the robot must use one of the above-listed power sources.
- 6. 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.
- 7. The robot and arm mechanism must be assembled by the team prior to the competition.
- 8. All robots will be required to pass inspection by judges to determine if all the parts used are from the list of allowed parts.
- 9. 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.
- 10. Robot wiring must be secured to chassis free and clear of any moving parts to avoid entanglement while competing.
- 11. Team members will be required to follow proper safety procedures and use eye protection in pit areas when working on their robot.
- 12. Teams may bring a laptop computer and blueprint drawings of their robot and arm mechanism designs to the competition building area. A description of the assembly process must be in the Engineering Notebook. The designs also may be printed or hand-drawn copies.
- 13. Teams must be composed of two (2) 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.

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: All teams will adhere to the official rules for the Urban Search and Rescue Challenge competition and compete positively and professionally. Team members must wear safety glasses while in the competition area.

- 1. At the competition, all teams must complete the five (5) standardized skills trials prior to the simulated search and rescue mission in accordance with the event schedule.
- 2. Teams will demonstrate proficiency in the following five (5) standardized skill trials:

- a. Arm mechanism trial – open three (3) mailboxes and remove ordnances. Each mailbox will progress in difficulty. For example, each mailbox might be taller than the next; the specifications will not exceed those noted in the Competition Guidelines above.
 - b. Navigation trial – pick up and maintain control of an ordnance while driving to specified disposal areas of the field.
 - c. Drive chassis trial – traverse various terrains and multilevel obstacles. For example, obstacles may include ramps, teeter-totters, and simulated debris.
 - d. Camera POV trial – navigate the robot through an obstacle using only a camera in first-person point of view without the help of a spotter, approach an ordnance, and pick it up. Examples of the obstacle could be a tunnel or the interior of a house.
 - e. Communication and collaboration trial – navigate the robot through a specified course without the assistance of a camera using direction and information from a spotter only.
3. For the simulated urban search and rescue mission, multiple ordnances will be placed within the challenge course. A total of three (3) ordnances will be hidden within the course. The placement of the ordnances will be varied in difficulty level based on the competitor's division: middle, high, and post-secondary. Each division will have specific parameters with multiple locations of similar difficulty for the placement of ordnances so that runs can vary from one run to the next. The main challenge will be considered complete upon the successful collection and disposal of two main challenge ordnances. A unique bonus ordnance will be available for collection and disposal within the given timeframe only after the two main challenge ordnances have been successfully collected and properly disposed. Clarification on ordnance placement on the field per competition level will be outlined during orientation at the national competition.
 4. At the competition site, the skills trial fields and simulated urban search and rescue field will be provided and maintained by the technical committee. During competition, the fields will be reset to their original state and the ordnance pieces will be placed before each team competes.
 5. Each team will operate its mobile robot and navigate by first-person POV through the video feed from an onboard wireless camera. The command center will be within view of the playing field. The designated driver must remain seated at the command center while the designated spotter remains in the defined spotting area while competing.
 6. An official will supervise the placement of each team's robot at the starting point on the challenge field.
 7. After a "clear" signal is issued by a challenge course official, time will begin as soon as the robot moves. Time will stop following successful completion of a trial or mission upon return to home base before the time limit expires.
 8. Time limits for completing each skill trial are as follows: **Note:** The time limits and number of trials are estimates only and are subject to change based on the number of teams competing. All teams will have the same time limits and number of trials.
 - a. Arm mechanism trial – three (3) minutes
 - b. Navigation trial – three (3) minutes
 - c. Drive chassis trial – two (2) minutes
 - d. Camera POV trial – two (2) minutes 30 seconds

- e. Communication and collaboration trial – three (3) minutes
9. The simulated urban search and rescue mission will last a maximum of six (6) minutes.
10. Team members are not allowed to touch their robot at any time while a trial or mission is in progress, unless instructed to do so by a judge.
11. For the urban search and rescue mission, 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.
12. Points will be awarded for the skills trials and urban search and rescue mission based on the official competition rubrics.

Penalties

1. A deduction will be assessed each time an ordnance is dropped.
2. Each time the robot stalls or becomes stuck and must be freed by officials, a deduction will be assessed.
 - a. A team member must officially request a rescue from a judge, at which point the judge will rescue the robot.
 - b. **Rescue type one:** Robot turns over and needs assistance to right itself. The judge will upright the robot, and the team can continue from current location with only a one (1) point deduction penalty.
 - c. **Rescue type two:** Robot becomes disabled due to mechanical failure. The judge will rescue the robot and bring it back to the starting position. Time will continue with a one (1) point deduction. Spotter can take the robot back to the driver for repair. The driver cannot leave the driver station and robot must resume from the starting position.
 - d. Each team will have a maximum of three (3) rescues in any combination.
 - e. A request or need of a fourth (4) rescue will automatically end the team's run.
3. Due to safety concerns, any battery that becomes partially or fully detached from the robot during a run will immediately halt the run. Time will stop, the team will incur a penalty, and the judge will retrieve and bring the robot and battery to starting position. The spotter will have one (1) minute to reattach the battery in the starting position to resume the run. If the battery is not attached within one (1) minute, the run will end. If the battery becomes detached a second time, the run will automatically end. A penalty will be assessed for deliberately moving the containment unit from its starting point.
4. 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.

URBAN SEARCH AND RESCUE CHALLENGE BILL OF MATERIALS

Part Description	Quantity
4" Wheel	6
16-tooth Sprocket	4
24-tooth Sprocket	6
32-tooth 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" Stand-off Post	12
1" Stand-off 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" Socket Head Cap Screws	200
Hex Keys	1
Zip Tie Pack	20
Kep Nut	200
3/8" Button Head Cap Screws	50
NiMH Battery Charger	1
4ch R/C Controller	1
288 mm Flat Bar	4
Servo Pivot w/Bearing	1
80-tooth Gear	2
40-tooth 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" by 24" sheet of acrylic plastic, maximum thickness of 0.250"
3. One 12" by 24" sheet of aluminum, maximum thickness of 0.080"
4. 3-D-printed parts of original design
5. Raw material used for fabricating custom robot part

STANDARDS AND COMPETENCIES

USR 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.

USR 2.0 — Produce technical documentation.

- 2.1. Keep an engineering notebook detailing design discussion, 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.

USR 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.

USR 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 drivetrain of the robot.
- 4.4. Demonstrate and explain the functioning of the package delivery system of the robot.

USR 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.

USR 6.0 — Demonstrate teleop skills and real-time problem solving.

- 6.1. Demonstrate ability to maneuver the robot safely and quickly 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.

USR 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.

USR 8.0 — SkillsUSA Framework

The SkillsUSA Framework is used to pinpoint the Essential Elements found in Personal Skills, Workplace Skills, and Technical Skills Grounded in Academics. Students will be expected to display or explain how they used some of these Essential Elements. For more, visit: www.skillsusa.org/who-we-are/skillsusa-framework/.

COMMITTEE IDENTIFIED ACADEMIC SKILLS

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

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: 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.

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.