

# **SkillsUSA**

## **2015 Contest Projects**

### **Robotics and Automation Technology**

Click the “Print this Section” button above to automatically print the specifications for this contest. Make sure your printer is turned on before pressing the button.



TEAM # \_\_\_\_\_

# 2015 SKILLS USA CHAMPIONSHIP

## ROBOTICS AND AUTOMATION TECHNOLOGY

### **Robotics and Automation Technology**

Challenges two-person teams to demonstrate operation of a five-axis servo-robot along with a set of sensors and motorized devices to resolve a simulated production process problem. Teams set up and demonstrate operation of a robotic workcell from a word problem. Contestants are required to create a flow chart and sequence of operation. Teams are also judged on efficiency, speed and teamwork.

# TEAM GUIDE

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## Acknowledgments

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The following are contributors to the 2011 Skills USA Championships, Robotics and Automation Technology competition:

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## **Technical Committee**

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## **Educational Committee**

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The following individuals contributed their time and energy to the Educational Committee.

## **Judges**

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The following individuals contributed their time and energy as Judges for the competition.

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# 1: Contest Overview

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## 1.1: Introduction

This document describes the Skills USA Championship 2015 Robotics and Automation Technology Competition and includes all related paperwork. This document may be used as a blueprint for state, regional, or local competitions.

## 1.2: Cutting-edge Technology

Robotics and Automation encompass a large part of manufacturing technologies. The integration of these processes within the manufacturing industry has allowed the United States to remain competitive within today's global market. Installing new, up-to-date systems in a timely manner is highly beneficial to remain competitive in the industrial market. The ability to change an existing system to a more efficient operation saves time in bringing a new product to market and reduces production time, thus lowering production costs.

To maintain industry leadership in this evolving field, it is essential that the labor force remain at the forefront of both current and emerging technologies in design and manufacturing. With today's complex manufacturing challenges, no individual can be expected to be an expert in all areas, so it is imperative for manufacturers to combine the resources and abilities of a team to resolve problems.

## 1.3: Your Team

Workers in the field of Robotics and Automation often find success in using a team approach. In the interest of emulating industry, this competition will be structured in this manner. For optimum team efficiency, we suggest your team be comprised of one specialist in each of the following fields:

- Robot Programming
- Electro-mechanical Integration

## 1.4: Statement of the Problem

Your company, Robotics and Automation Inc., has assigned you and your teammate to compete for a lucrative contract designing new production lines for SCORBOT Robotics, Inc. The engineering department has provided you with a description of the required process and a list of equipment and material available for use in system design and implement. **Your assigned team number will be you team name.**

Quality and production costs are essential in remaining competitive in the manufacturing industry. Therefore, project completeness, elapsed time off-line, cycle time, and implementation techniques will all be considered as part of your evaluation.



## 2.: Contest Guidelines

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### 2.1.: Implementation

Using the description of the process and the provided equipment and materials, you must layout your production system and develop a robot program to fulfill the requirement of the task. Complete project documentation at each task level is required. Documentation must include: a sketch of the layout and equipment placement, a flow chart of the program, terminal strip assignments and Input/Output assignments.

### 2.2.: Task Level Update Requirements

This project is broken into multiple “Tasks”; each requiring program and layout updates. Documentation for each section must also reflect your team’s proposal for the current assigned task.

### 2.3.: Guidelines

The project manager has provided the base outline of the materials within this document to begin your planning and implementation. Your success on this project is based upon the following criteria:

- A. Providing complete documentation of the project at each task level\*.
  - 1. Flow chart
  - 2. System hardware layout
  - 3. Controller interface - input and output assignments
  - 4. Terminal strip assignment
- B. Using the proper technology for the preparation of the documentation
- C. Packaging the documentation in an orderly and professional manner
- D. Effective use of teamwork in managing the project
- E. Safety in the manufacturing process
- F. Efficient use of time, material and resources

\* Documentation at each task level should be presented for just the requirements of that task level assignment.

### 2.4: Team Guidelines

Your team should follow these guidelines:

- 1. Primary responsibilities and duties are organized.
- 2. A team leader is identified to interact with Technical Committee representatives.
- 3. Your team decides upon appropriate break times with the exception of the mandatory lunch break.
- 4. Breaks are to be taken within assigned individual work areas.
- 5. Team members must be escorted by a member of the SkillsUSA Courtesy Corp. or by a contest judge when taking a bathroom break. Only one team member is allowed to leave the contest area at a time.
- 6. SCORBASE software for the SCORBOT ER-4u has been provided to you and is loaded on the provided computer.
- 7. Save your program/work often. You must save your final programs.
- 8. You will be notified of your contest final completion time. Only a stopped clock as referenced in section 2.5 will allow additional time.

### 2.5: Equipment Malfunctions Considerations

IN THE CASE OF A SOFTWARE OR HARDWARE FAILURE: Your team must notify a contest judge or member of the Technical Committee of any suspected hardware or software malfunction. If it is determined that it is in fact a software or hardware failure, the running time clock will be stopped for that team until the malfunction is corrected. System “down-time” will be added to the effected team’s contest end time so that all team’s have the same total contest duration. In the

case of a stopped time clock, all work will stop for the entire team until the problem is resolved. It is important to notify a contest judge as soon as a malfunction is suspected. No extra time allowance will be granted for malfunctions prior to notifying a judge.

## **3: Official Competition Overview**

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### **3.1: General Information**

This is an official SkillsUSA Championship sanctioned competition. This competition is unique due to its dual technology, team-oriented concept and intensive use of hardware and software.

### **3.1: Purpose**

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#### **3.1.1: Goals of the Competition**

*To evaluate each contestant's preparation for employment in* the emerging arenas of robotics and automation team approach to problem solving in the work environment. To recognize outstanding students for excellence and professionalism in their chosen field.

### **3.2: Clothing Requirement**

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#### **3.2.1: Correct Attire**

- official khaki work shirt
- official khaki work pants
- approved leather work shoes
- CLEAR safety glasses with side shields or goggles (prescription glasses must be covered with goggles unless they are equipped with side shields)

Refer to General Regulations and Robotics and Automation Technology, Page of the current SkillsUSA Championships Technical Standards.

### **3.3: Eligibility**

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#### **3.3.1: Qualifications**

This competition is open to active SkillsUSA members enrolled in programs with robotics, electro-mechanical, or automated manufacturing as their occupational objective.

## **3.4: Scope of Contest**

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### **3.4.1: Team Organization**

Teams of two will demonstrate their ability to perform, exhibit, and compile skills and knowledge necessary from the following list of competencies determined by the Robotics and Automation Technology Skills USA Technical Committee Members.

The team will be provided with a written description of the task requirements and a list of the available equipment and materials. The team will develop a system design and robot program proposal, and upon the judge's approval will configure and demonstrate their product. Upon successful completion of each task level, they will be provided a requirement to refine their system design and again demonstrate the reconfigured system's functionality.

### **3.4.2: Required Competencies**

Successful competitors possess the following skills:

- A. Perform analysis of task**
  - 1. Evaluate written task
  - 2. Evaluate provided equipment and material
  - 3. Evaluate system task revisions
- B. Design, Sketch and Plan**
  - 1. Determine sequence of operation
  - 2. Select equipment and material to meet functional need
  - 3. Create Flow Chart
  - 4. Create layout
  - 5. Create Input and Output Assignment
  - 6. Create Terminal Strip Assignment
  - 7. Process system revisions for different task levels
- C. Implement Design**
  - 1. Develop robot program
  - 2. Install equipment
  - 3. Integrate equipment with system controller
  - 4. Modify system to meet task revision requirements
- D. System Performance**
  - 1. Perform functional test for total system operation
  - 2. Present system for evaluation
  - 3. Perform functional test to meet stated task requirements
  - 4. Present revised system for evaluation

## 3.5: Group Organizational Goal

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### 3.5.1: Team Dynamics

The competition is run much like you would expect in industry; with both team members interacting and demonstrating good teamwork to achieve the team's task assignments. The robot programmer will program the robot and peripheral equipment. The Electro-mechanical integrator will install the peripheral equipment and integrate it into the system.

The contest is designed to promote creativity in organization of production responsibility. Teams should divide duties among all team members. **Each team member must take an active role in this competition.** No one individual should dominate by taking responsibility for more than one project specialty. When a team member has spare time, they will help their teammates. All Team members are responsible for double-checking each other's work and quality control.

## 3.6: General Information

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### 3.6.1: Necessities

The following items are required to compete in this contest:

1. This competition will be carried out using Intelitek's ER4u robot, linear slide base, conveyor, and teach pendant.
2. SEIMANS PLC (pre-programmed)
3. Other equipment and material is from local supply sources.
4. Each team will be provided with one computer unless otherwise notified previous to competition.
5. Teams will consist of two members.

## 3.7: Team Goals

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### 2.7.1: Team Objectives

1. To have every team complete the competition.
2. To have each team member demonstrate reading and writing skills.
3. To have each team member use their critical thinking and problem solving abilities in the contest.
4. To have each team member illustrate responsibility, teamwork, self-management skills, and professionalism.

## 3.8: Contest Notebook

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### 3.8.1: Supplied Documentation

Each team is issued this notebook and information packet. The contents of the supplied documentation completely define the requirements of the contest and include templates for the required project documentation. Additional copies of the templates may be requested from the contest judges.

### **3.9: Required Equipment, Tools, & Materials**

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Teams require the following materials to complete the competition. The Technical Committee provides many of these materials, but the teams must also bring certain items.

#### **3.9.1: Workstation Components Provided by the Technical Committee:**

1. SCORBOT ER-4u robot mounted on a linear slide base
2. Teach Pendant
3. Conveyor with a Photo sensor
4. Pneumatic press with position sensors
5. Pneumatic parts feeder
6. Sensor Box with a Micro switch and a Proximity sensor
7. Mounting platforms
8. Plastic and Metal blocks
9. Computer at each station with SCORBASE software installed
10. Printer
11. Contest Notebooks
12. Task assignments (in contest notebook)
13. AC Power at each station
14. Air for pneumatic equipment at each station
15. Siemens S7-1200 PLC

#### **3.9.2: Team Provided Components**

Teams Provide (tool boxes will be inspected):

1. Wire cutters/diagonals 3" to 6"
2. Wire strippers
3. Long nose/needle nose pliers 3" to 6"
4. Screwdrivers (3" to 6" blade length)
  - Common Set to include 1/8", 1/4" & 3/8" minimum
  - Phillips Set to include # 0, # 1 & # 2 minimum
5. Standard Safety glasses, clear lens only, for each constant
  - Colorized Lenses are not accepted
  - Sun Glasses are not accepted
6. Pencils 2 (sharpened)
7. 6" or 12" ruler
8. Hookup wire is required, 20 – 24 AWG,
  - 5 different wire colors
  - Recommend 150' of each color

NOTE:

- Points will be deducted for items listed and not provided by the team.
- You will not be permitted to borrow from other contestants
- SkillsUSA Clothing – See the SkillsUSA - Technical Standards for specific information

### 3.9.3: Team Provided Components - Optional items:

Teams may also provide:

1. Intelitek Documentation: This documentation can be downloaded and brought to the contest by each team. The Technical Committee will not be providing a paper copy of this documentation at the Skills USA National Competition. It will however, be installed on each computer as a .pdf file.
  - SCORBOT ER-4U User Manual
  - Controller USB User Manual
  - SCORBASE User Manual
  - Teach Pendant User Manual
2. Power screwdriver (with cross point and common bits) to mount components to platform
3. Watch with second hand, digital counter, or stopwatch
4. Allen wrenches, Set to include 5mm, 3mm and 7/64" minimum
5. Flow Chart Template
6. Multi-meter with leads
7. Tie Wraps

Note: ONLY the above listed items will be allowed in the contest area during the competition.

## 3.10: Division of Duties

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### 3.10.1: Suggested Department Contributions

Task analysis	Both team members
System layout	Both team members
Robot program	Robot programmer
Equipment placement	Electro-mechanical integration tech
Electrical integration	Electro-mechanical integration tech
System layout sketch	Electro-mechanical integration tech
Program flow chart	Robot programmer
Notebook	Both team members

## 4: Safety

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### 4.1: Importance of Safety

In industry, it is imperative to maintain a safe work environment. Federal Occupational Health and Safety Laws now mandate safe work environments for the U.S. workforce and failure to comply can result in significant fines and forced work stoppages. On the other hand, when a company's history of incidents resulting in injury is minimal, the company increases its likelihood of reduced insurance rates and workman compensation fees.

Safety considerations will be taken into account during judging to further replicate a professional industrial environment.

### 4.2: Safety Violations

If a team or a team member violates a safety rule, or operates their work cell in an unsafe manner, the following penalties will be enforced:

1st Violation:

Team will be issued a written warning.

2nd Violation

Team will have 50 points deducted from their total score.

3rd Violation

Team will be disqualified.

### 4.3: Avoiding Safety Hazards

Some safety issues:

1. The Emergency Stop Switch must be depressed when working on an active system other than when an active system is required to accomplish a required part of the task, such as teaching the robot positions.
2. Team members must wear safety glasses when they are in proximity of an operational system or performing tasks that require safety glasses, such as cutting and stripping wire.
3. Team members must keep their work area reasonably clean. Clean work places promote efficient and safe working conditions.
4. Team members must keep their teammates and other teams aware of possible dangerous situations, such as flying chips, noise, possible tool breakage, etc.

**Overall safety is not limited to the above rules. Unsafe acts or practices will not be tolerated and can be grounds for immediate disqualification. Judges decisions on safety are final.**

## 4: Practice Session

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### PRACTICE SESSION BRIEFING

1. Welcome and congratulations on making it to the SkillsUSA – Robotics and Automation National Competition.
2. This is an official Skills USA Championship contest that was approved by National SkillsUSA in 1998.
3. While in the work area please observe all safety precautions. Unsafe acts may disqualify you from participating in the actual contest.
4. No Cell Phones. Please notify judge or committee member if you need a bathroom break. 1 Team member at a time.
5. Today is a practice day for you and your teammate to familiarize yourself with the supplied contest equipment. This morning your advisor is welcome to help you get setup and become familiar with the system and its components. Set up your computer, controller, slide base and robot by following the *Instructions for Robot Setup*
6. You will be introduced to equipment that you will use in the actual contest. You will be given time and necessary help, if needed, to write programs that will test all of the components.
7. The equipment other than the Robot, Slide Base, Teach Pendant, Stack light, PLC and Emergency Stop will not be secured to the platform during this practice session.
  - Make sure you know how to operate the stack lights, sensor box, feeder and press.
  - Count parts
8. Power – We will be checking all power connections prior to providing a power cable.
9. Today (**Tuesday**) you will also be taking a written exam. We will split everyone into two groups. One group will practice on the hardware in the morning and the other will take the written exam. We will then swap in the afternoon.
10. The contest will be held on Wednesday and Thursday this week. The teams practicing on the hardware in the afternoon will compete on Wednesday, the other teams on Thursday.
11. Please review the required materials section of the contest. This is your chance to make sure you have the appropriate tools and cabling.
12. Safety glasses, clear lens only for each constant. Colorized lenses are not accepted. Sunglasses are not accepted.
13. You cannot create a wire harness today, and use it for the competition tomorrow.
14. No Cell Phones!
15. Competition Day - Tomorrow we will meet at 7:30 am in Lobby 2400. Same place as today!
16. Please stay at your contest area until told you can leave. All contestants must be escorted from the contest area at the same time. Your work area must be clean and approved by a contest official before leaving.
17. Today is the day to ask questions, Thank you and good luck.



# INSTRUCTIONS FOR ROBOT SETUP

1. **The Robot platforms have been positioned on a table in their desired location.**
2. The Robot, Slide Base, Stack Light, Emergency Stop, PLC and Teach Pendant are fastened to the platform. These are the only pieces of equipment that have a permanent home. The remaining equipment and material will be placed as you see fit to enhance your system setup.
3. You have been furnished with instructions, Spec & Doc, data sheets and/or schematics of the supplied equipment. Use the provided literature to determine how to connect the devices correctly.
4. Activate SCORBASEpro software as described in the Scorbace User's Manual page 6.
5. Activate the SCORBASE program by double clicking on the SCORBASE Icon. Click on File pull-down. Select *New Program*. Then select *pro* on the Task Bar. You should now be in SCORBASEpro program.
6. Connect the Linear Slide Base to axis 7. The Slide Base may be left connected. Click on File pull-down. Select *New Program*. Click on Options pull-down. Click on *Hardware Setup*. Select *Peripherals*. Select *axis 7*. Select *Slidebase 1.0 m Belt-drive*. See page 80 in the Scorbace Users Manual.
7. Home the robot and slide base as described in the User's Manual page 12.
8. The setup is complete.

**We are here to help you today. Please feel free to ask a committee member for assistance today!**

# SETUP AND PRACTICE

1. Do not proceed unless you have finished the Robot Setup.

**Note:** All Output connections will be made to the Controller interface panel. Do not make any connections to the controller box except the Emergency Stop switch and axis 7& 8.

2. You will be asked to write simple programs to test the inputs as you connect equipment to them. Use the SCORBASE for the ER-4u user manual.
3. Connect the 12-volt power supply to the interface board.
4. Connect the switch from the sensor box to the controller interface. Connect one wire to ground terminal and the other wire to one of the inputs. Actuating the switch should illuminate the LED associated with the input to which you connected the wire. Write a program to test this input when the switch is actuated.
5. Using the specifications from your notebook, Connect power to the proximity Sensor. Connect the sensor box to the controller interface. Test the sensor by holding a metal block near the sensor, did the controller input LED illuminate? Write a program to test this input.
6. Connect the Emergency Stop switch to the Controller. Use the Controller-USB User Manual for additional information. Ask a contest Official if you need help. Test the Emergency Stop switch. Depressing the Emergency Stop switch should stop all movement of the Robot and Slidebase.
7. Practice moving the robot and slide base in both the Joint and XYZ modes. Use the mouse, keyboard and teach pendant.
8. Practice teaching the robot and slide base positions.
9. Write short programs to verify the positions you have taught. Remember to SAVE your work FREQUENTLY.
10. **Connect the Pneumatics Parts feeder Solenoid to an output of the PLC.** Connect the Part Present Limit Switch, and the feeder limit switch to inputs. Write a program to test both solenoid (output) and switches (inputs).
11. Write a short program to cause the Robot to pick up a part if present and open and close gripper if no part is present.
12. Stack Lights. Look at the Stack light specifications to see how the stack lights are to be used and connected.
13. Pneumatic press with position sensors, you will hook up pneumatic lines during the contest and use cylinder position sensors to determine if cylinder is up or down.
14. PrintToScreenLog command. You will be asked to use this to document several aspects of the contest> Refer to the contest specification on how to use this command. Practice using this command.
15. The drawing of Flowcharts has not been addressed during this session; however you will be expected to develop a flowchart during the contest. We suggest reviewing this with your advisor.
16. REVIEW ALL CONTEST MATERIAL TODAY. So you are ready for the contest.

**NOTE:** You are not allowed to bring in any wire harnesses created from the practice day to the contest.

## PRACTICE DAY WRAPUP

1. Leave all of your scratch paper, notes, usb drive, etc. in the notebook.
2. Toolboxes may be left a location to be designated by a contest official.
3. Turn in the notebook to a contest official before you leave the contest area.
4. Insure that all notes and disks are left in your binder.
5. Please stay at your contest area until told you can leave. All contestants must be escorted from the contest area at the same time. Your work area must be clean and approved by a contest official before leaving.

**IF IN DOUBT ASK**

**See you on your contest Day**

**GOOD LUCK!**

## 5: Competition Introduction

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### 5.1: The Client

SCORBOT Robotics, Inc. has been providing high quality affordable structural blocks for commercial and consumer use since 1959. As our business grows, so does our need to become more efficient and cost-effective in our manufacturing facilities. We see a future cost and quality benefit in the automation of our production process, and we desire a robotic workcell to manufacture our structural blocks.

### 5.2: Supplied Equipment and Materials

Our corporation will be providing automation hardware to all firms competing for our business. The hardware specifications are listed in the documentation that has been provided.

These workcell components are:

1. Computer with SCORBASE software
2. ER-4u robot, Controller, Controller Interface, and Cables
3. Teach Pendant
4. Linear Slide Base
5. Conveyor with photo-sensor
6. Electro-Pneumatic Parts Feeder with part in stack switch and part in place switch
7. Electro-Pneumatic Press with cylinder position sensors
8. Interface Board for all Input and Output connections
9. Stack lights (Red, Green, Blue and Yellow)
10. Storage area template
11. Sensor station with proximity switch and micro switch
12. Bad parts bin
13. Emergency stop switch
14. Blocks, structural, of varying materials
15. DC Power Supply and power terminal strip
16. E-Stop switch
17. Power strip and extension cord
18. Task assignments
19. Notebook
20. Mounting platform
21. Pressurized air supply for pneumatic equipment operation
22. Siemens Programmable Logic Controller (PLC with program)

### 5.3: Additional Supplied Hardware Information

SCORBOT Robotics, Inc. is supplying a SCORBOT ER4u robot mounted on a linear slide base in the center of work platform. This provides a work envelope on either side of the slide base. The Robot Controller Interface and Siemens PLC has been mounted to the platform. The Emergency Stop switch and Stack Lights are attached to the rear corner while the Teach Pendant is on the front corner of the platform opposite the controller. All remaining hardware may be placed on the platform at your discretion to enable efficient implementation of your solution. As you plan the placement of these hardware items, your system proposal should provide for future expansion to add more features and capabilities for future task designs.

## 5.4 Stack Lights:

Before any robot motion, and for certain other actions, safety warnings must be given. The Stack Lights will be used to signal safety conditions. Illumination of the appropriate light at the proper time is essential. As events occur, the Stack Lights must illuminate the proper color to indicate the event. See Stack Light Usage Section for all signal requirements.

## 5.5: Evaluation

The competition has been **split into 2 separate tasks**, each task building on the prior task. When your team has completed the design for the workcell, you will notify a representative from SCORBOT Robotics Inc. to review your proposed solution. This design must include the workcell layout and appropriate documentation. (See documentation Tab 5)

Once your design is approved, you will receive a green tag, allowing you to complete the operational phase of the task. Once you are ready with the operational phase, you will notify a representative from SCORBOT Robotics Inc. to review the operation of the workcell.

**SCORBOT Robotics Inc. will use the following criteria during the initial interview to evaluate your proposal for each task:**

- Team is ready to discuss proposal and implementation.
- Both team members active in discussion.
- Flow chart documentation is complete.
- Hardware layout documentation complete.
- I/O documentation complete.
- Robot Positions documentation started

**For the operational phase of the task, SCORBOT Robotics Inc. will review the following:**

- Hardware layout matches documentation.
- Wiring connections match documentation and the cell is neat and organized.
- Flow chart aligns with program.
- Operational phase will be judged.
  - ✓ Have all parts available for judges to select loading order.
  - ✓ Wait for judge to arbitrarily select the order parts are to be loaded into the parts feeder.
  - ✓ A Judge will load the parts.
  - ✓ When instructed by a judge you will nm the program.
- Stack Light Operation
- Part Testing
- Part Feeder Operation
- Part press Operation
- Part placement
- Ready to discuss Implementation
- Both Members Active in discussion

## 6: Task One

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### 6.1: Overview

SCORBOT Robotics Inc. is currently seeking a firm that can provide the most efficient automation solution through written proposal and demonstration.

Your team's assignment is to assess the requirements of the Task One specifications and then to develop a proposal on how you plan to accomplish this task. This proposal must include the appropriate documentation for SCORBOT Robotics, Inc. to review in order for your team to gain the judge's approval to build and program the proposed system.

### 6.2: Evaluation

When your team has completed the design for the workcell layout and the appropriate documentation is completed, notify a representative from SCORBOT Robotics Inc. (Judge) to conduct a review of your proposed solution. Once approved, you will be provided a power cable to complete the work cell hardware for demonstration to the judges.

### 6.3: Required Documentation

SCORBOT Robotics Inc. managers want to see a complete and full proposal that will include all schematics, flow-charts, drawings, layouts, and request a meeting with the vendor before the demo is setup and run.

1. Proposed System layout for the specified task.
  - a. Hardware Layout (Drawing).
  - b. Robotic Interface – Input and output connections.
  - c. PLC Connections
  - d. Peripheral hardware connections.
2. Flow chart of proposed robotic program.
3. Any additional supporting documentation as required.

### 6.4: Initialization:

The plastic and metal blocks will be placed in the "automated parts feeder" in random order with the holes facing down. When the parts feeder is activated, (parts are loaded, sensor switch is activated) a block will be pushed out of the shoot, and will activate (press) the micro switch. The robot should wait for the specified amount of time after the block is in place. Use an assortment of all 8 available blocks. Remember, a contest judge will be placing the blocks in the feeder in random order during judging.

### 6.5: General Task Description

SCORBOT Robotics Inc. wants to automate a "hole" punch operation and quality inspection for our model A, plastic and aluminum blocks. The feeder is equipped with multiple switches to detect when the feeder stack is empty and when a block is in position for robotic pick-up. This will require the system to monitor the automated parts feeder stack for the presence of a block (Block loaded in the feeder stack). The system will then use the air cylinder to feed a block out of the feeder stack, where it will activate a sensor to notify when a block is in position for robotic pick-up. The robot will then take the block from the automated parts feeder, punch a hole in it, inspect the hole and determine whether the hole punch process was successful and the block has a hole. Blocks without holes are to be considered "bad" or "failed" blocks. Blocks with holes will be placed on the appropriate paper templates, within the lines for shipment.

Cycle time is again very important to SCORBOT Robotics Inc. After a full cycle has been run, a second test will be run to track cycle time. Cycle time will be counted on a final run of 4 blocks, one of each type with and without a hole.

### General Task Description - Continued

#### Metal and Plastic Block processing

Both of our block types (Metal and Plastic) will be running on the same line. However, the holes in the aluminum blocks will need to be punched and held for 20 seconds and the Plastics blocks will need to be punched and held for 10 seconds.

NOTE: When a block is in position to be picked up, the robot shall delay for 5 seconds before retrieving the block. The system shall sound an audible alert from the computer, and the appropriate stack lights must activate when tasks begin, when the robot begins its cycle and when the punch is activated.

The lights must correspond to the operations indicated in the Stack Light Specifications Section in your 3-ring binder. SCORBOT Robotics Inc. is requesting that you provide a written document **after the demo** has been completed that notifies us in writing of any safety issues or improvements that they feel should be addressed.

## **6.6: Key Specific Task Requirements**

- Refer to Stack Light usage Section for all signal requirements.
- Sensors must be implemented to determine if part is in the feeder and when a part is in pick-up position.
- Robot must wait 5 sec after a block is pushed out of the feeder shaft before moving sensor is pressed.
- Robot will use a sensor to determine type of block (metal or plastic).
- Robot must punch plastic blocks for 10 seconds and metal blocks for 20 seconds.
- Robot will use a sensor to inspect and verify the presence of a hole in block.
- Robot must beep when cycle has started and before punch moves
- Each team shall provide SCORBOT Robotics Inc. with a paperwork proposal at a meeting where the proposal must be approved before actual work on the robot system may begin. This paperwork should include schematics, layouts, descriptions, flowchart, overviews, and anything else they feel will show SCORBOT Robotics Inc. that they can complete the task
- Use paper storage area templates for good blocks having holes. Accuracy will be judged.
- Use bad plastic part bins to recycle the bad plastic and metal blocks without holes.
- Wiring will be judged, layout and neatness will count!

## **6.7: Notes**

- You may use the teach pendant to teach, re-teach, jog, or make any other movement of the robot and/or peripheral device.
- There are other related tasks that are to be performed at various different locations, see documentation
- The program shall continue to run waiting for additional blocks to be loaded.
- During evaluation phase, the judge(s) will randomly select the order the blocks are to be loaded into the parts feeder. Blocks will always be loaded with their holes facing down.

## 7: Task Two

---

### 7.1: Overview

SCORBOT Robotics Inc. is pleased with what you, our vendors have provided and is looking to upgrade the workcell. We are having quality and throughput issues. SCORBOT Robotics Inc. is looking to add a conveyor for the good parts for visual inspection and efficient storage processes.

Your team's assignment is to assess the requirements of the Task Two specifications and then to develop a proposal on how you plan to accomplish this task. This proposal must include the appropriate documentation for SCORBOT Robotics, Inc. to review in order for your team to gain the judge's approval to build and program the proposed system.

### 7.2: Evaluation

When your team has completed the design for the workcell layout with the appropriate documentation, notify a representative from SCORBOT Robotics, Inc. (judge) to conduct a review of your proposed solution for Task 2.

### 7.3: Required Documentation

SCORBOT Robotics Inc. is concerned with a few different issues that will arise. SCORBOT Robotics Inc. managers want to see a complete and full proposal of the updated changes that should include all schematics, flow-charts, drawings, layouts, and request a meeting with the vendor before the demo is setup and run. You may update your completed documentation from previous tasks or request blank copies from the judges.

1. Updated documentation
  - a. Hardware Layout with changes.
  - b. Robotic Interface - Input and output connections.
  - c. Peripheral hardware connections.
2. Flow chart of proposed robotic program.
3. Any additional supporting documentation as required.

### 7.4: Initialization:

As in the previously implemented task, the blocks will be placed in the "automated parts feeder" in random order with the holes facing down. Remember, a judge will be selecting and loading the blocks during a judging run.

### 7.5: General Task Description

The system will process the blocks using an automated parts feeder and operate according to all of the requirements of task 1, with the additional requirements listed below.

SCORBOT Robotics Inc. is adding a visual inspection process to the good blocks. After the Quality Control process has determined whether a block has passed or failed inspection, all good plastic and metal blocks will be placed on the non-sensor end of the conveyor for a visual inspection. After a good part is placed on the conveyor for a visual inspection. The conveyor will start motion and continue until it reached the sensor at the end of the conveyor. The blue stack light must be on while the conveyor is in motion. Once the part has reached the sensor and the conveyor has stopped. The robot will move the part to the storage template for shipment. The storage template can be placed anywhere on your worktable, but accessible for human intervention.

Note: Documentation in tab 4 section 18, reviews conveyor control

SCORBOT Robotics Inc. needs to save storage space and requires that you only use one storage template for good blocks. The good plastic blocks will be stacked on the left side of the storage template and the good metal blocks will be stacked on the right side of the storage template. Stack the parts two blocks tall for visual inspection and packaging.

### Parts Counters:



SCORBOT Robotics Inc. management is now requiring the blocks to be counted as they are processed using the robot's program counter log. Both good and bad parts must be counted and the Plastic and Metal counts must both be counted separately. The counters must be displayed with the PrintToScreenLog command.

- total number of metal blocks processed
- total number of plastic blocks processed
- total of all failed blocks

This log will be saved to a file and displayed to the screen.

## **7.6: Key Specific Task Requirements**

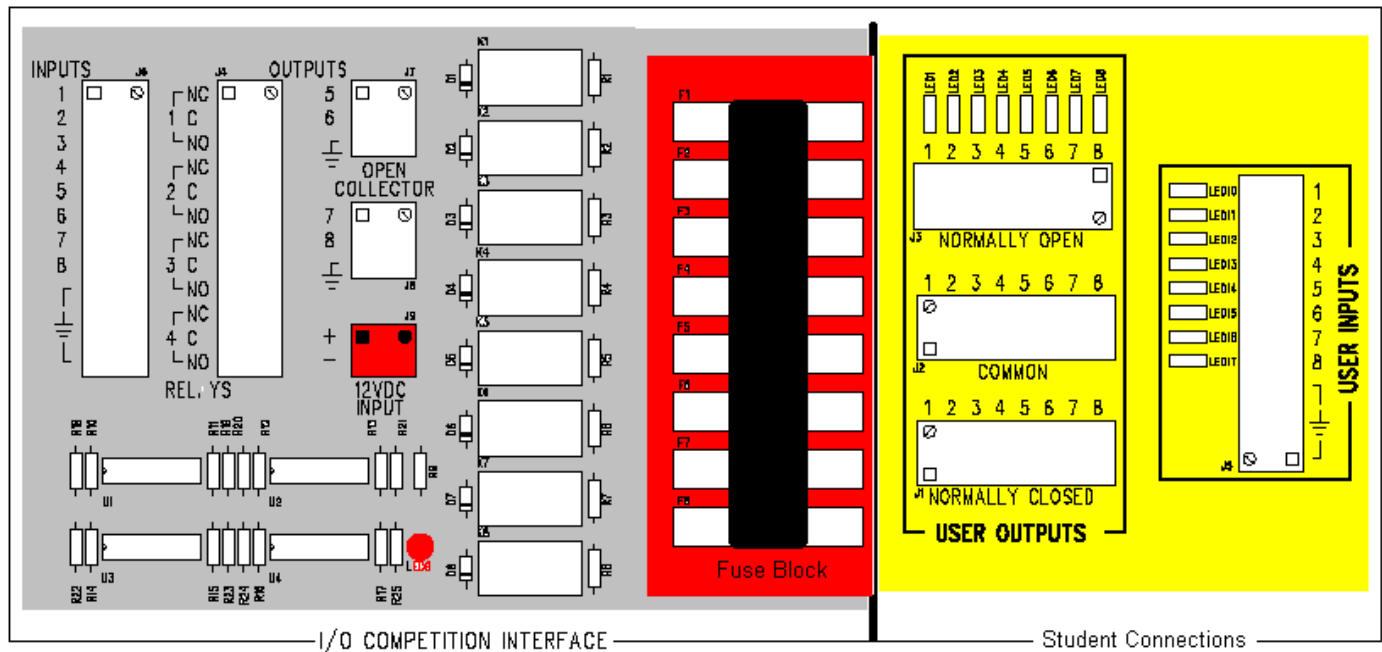
- Refer to Stack Light usage Section for all signal requirements.
- Good blocks will be placed on non-sensor end of the conveyor for visual inspection.
- The conveyor photo-electric sensor input is used to stop the conveyor.
- Each team shall provide SCORBOT Robotics Inc. with a paperwork proposal at a meeting where the proposal must be approved before actual work on the robot system may begin. This paperwork should include schematics, layouts, descriptions, flowchart, overviews, and anything else they feel will show SCORBOT Robotics Inc. that they can complete the task
- Use a single storage area template for good blocks having holes. Accuracy will be judged.
- Count and log the number of total good plastic & metal blocks, and bad blocks. Reset the counts to zero if the program execution is stopped.

## **7.7: Notes**

1. You may use the teach pendant to teach, re-teach, jog, or make any other movement of the robot and/or peripheral device.
2. There are other related tasks that are to be performed at various different locations, see documentation
3. The program shall continue to run waiting for additional blocks to be loaded.
4. During evaluation phase the judge(s) will randomly select the order the blocks are to be loaded into the automated parts feeder. Blocks will always be loaded with their holes facing down.
5. Cycle time will be counted.

## 9: Hardware Specifications - Controller Interface

### 9.1: Controller Interface

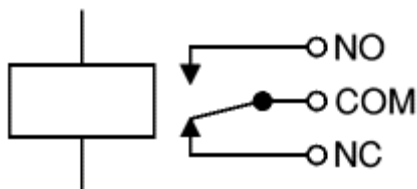


All Wiring connections are made from the Controller Interface from the Student connection side as shown above.

**User Inputs:** Connections are made from input devices such as sensors from the parts feeder. All connections require a ground connection and a connection to one of the eight inputs. **All Input signals must be wired to the I/O board.**

**User Outputs:** Connection from the controller to an output device. This is a SPDT relay (switch) with no power that will be wired to the PLC inputs. **All Output devices must be wired to the PLC outputs.**

The User outputs contain a relays which is a switch that can be turned on and off using the SCORBASE software. They are an electromagnetic switch, which means that a magnet is responsible for the state of the switch when the output is enabled or on.



Circuit symbol for a relay

COM = Common, always connect to this, it is the moving part of the switch.

NC = Normally Closed, COM is connected to this when the relay coil is off.

NO = Normally Open, COM is connected to this when the relay coil is on.

Connect to COM and NO if you want the switched circuit to be on when the relay coil is on. Connect to COM and NC if you want the switched circuit to be on when the relay coil is off.

**It is the responsibility of the contestants to verify that all fuses are in working order before the start of the contest. Points are deducted for a blown fuse during the contest.**

## 10: Hardware Specifications - Programmable Logic Controller

---

### 10.1: PLC Definition

#### DO NOT DISASSEMBLE THE PLC UNIT

A programmable logic controller (PLC) is a digital computer used for automation of electromechanical processes.

PLC's are armored for severe conditions and have the facility for extensive input/output (I/O) arrangements. These connect the PLC to sensors and actuators. PLCs read input devices such as limit switches, inductive sensors, proximity sensors and reed switches. Some use machine vision. On the output side, PLCs operate pneumatic or hydraulic cylinders, solenoids, or stack light fixtures.

PLC's are programmed in "ladder logic", which strongly resembles a schematic diagram. PLC programs are typically written in a special application on a personal computer then downloaded by a direct-connection cable or over a network to the PLC. The program is stored in the PLC either in battery-backed-up RAM or some other non-volatile flash memory. Often, a single PLC can be programmed to replace thousands of relays.

Digital input signals behave as binary switches, yielding simply an On or Off signal (1 or 0, True or False, respectively). Discrete signals are sent using either voltage or current, where a specific range is designated as On and another as Off. For example, the Siemens SIMATIC S7-1200 PLC used in your process uses 12 VDC I/O, with values above 10 VDC representing On, values below 2VDC representing Off.



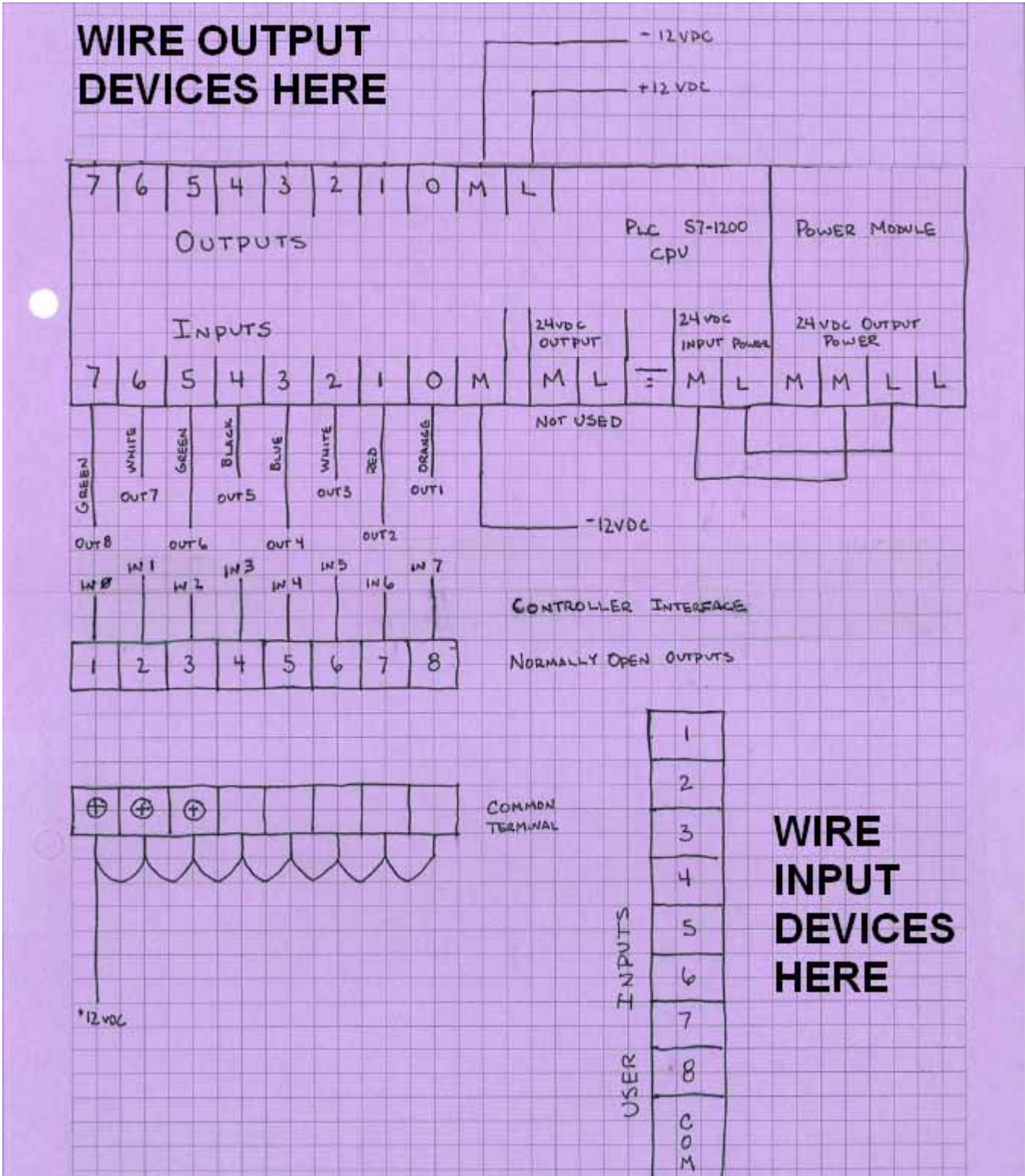
Figure 1: SIEMENS SIMATIC S7-1200

#### DO NOT DISASSEMBLE THE PLC UNIT

If you have Questions, ASK a contest official.

### 10.2 PLC WIRING DIAGRAM

All Input signals must be wired to the I/O board and all Output devices must be wired to the PLC outputs.



### 10.3 PLC Ladder Logic program

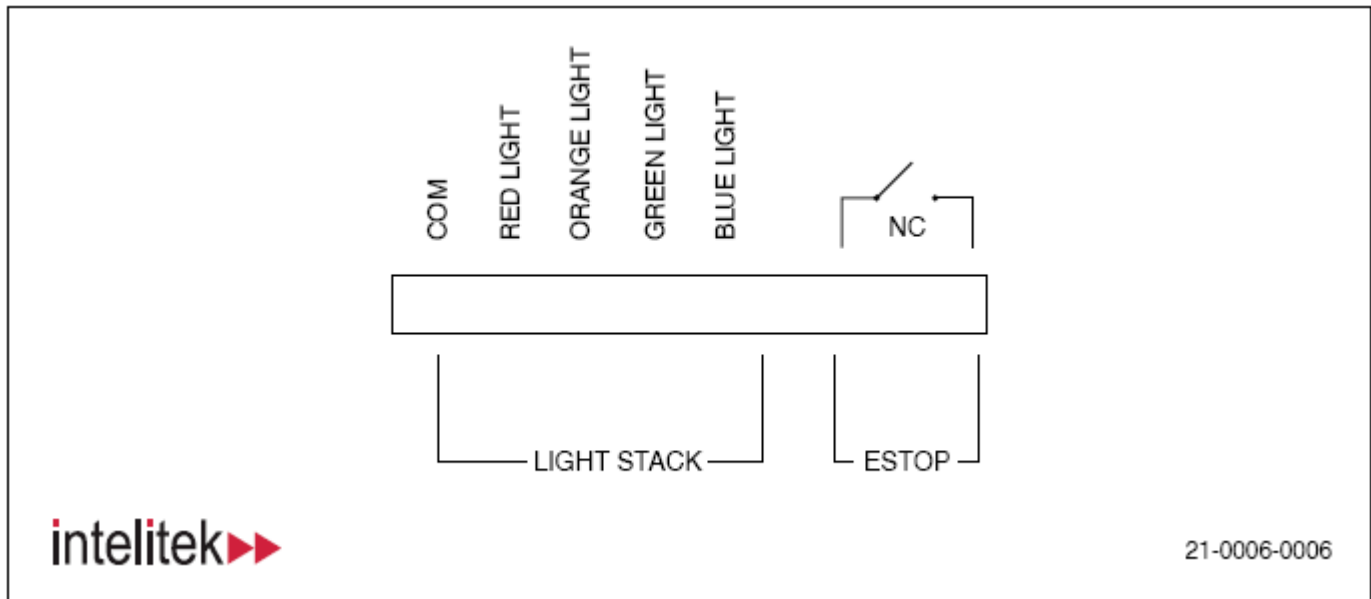
## 10.4. PLC I/O Description

- When Input 0 is High, Output 0 is High
- When Input 0 is Low, Output 0 is Low
- When Input 1 is High, Output 1 latches High permanently and flashes at 0.25 second intervals
- When Input 2 is high – Output 1 is low  
(Note: Input 2 must be Low for Input 1 to latch 1 and Input 1 must be low for Input 2 to unlatch Output 1)
- When Input 3 is High, , Output 3 is High
- When Input 3 is Low, Output 3 is Low
- When Input 4 is High, Output 4 is High
- When Input 4 is Low, Output 4 is Low
- When Input 5 is high – Output 6 is high for 10 seconds then turns low
- When Input 5 is low – Output 6 is low
- When Input 6 is high – Output 6 is high for 20 seconds then turns low
- When Input 6 is low – Output 6 is low
- When Input 7 is high – Output 7 is high
- When Input 7 is low – Output 7 is low

## 11: Hardware Specifications - Stack Light Usage

### 11.1: Stack Light Uses

**DO NOT DISASSEMBLE THE STACK LIGHT UNIT**



Stack Light requires 12 volts DC.

Color	Usage
Red	Flashing at 0.25 sec intervals when the robot motors have power and workspace is unsafe.
Yellow	ON during pressing operation.
Green	ON (solid) when SCORBASE program is not running and the work area is safe.
Blue	On when conveyor is moving.

**DO NOT DISASSEMBLE THE STACK LIGHT UNIT**

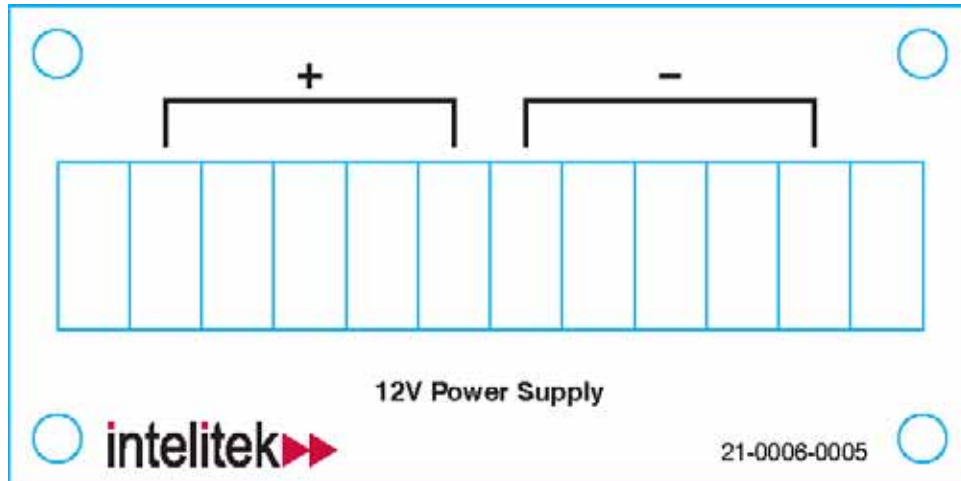
If you have Questions, ASK a contest official.

## 12: Hardware Specifications - Power Supply (12 Volt DC)

---

### 12.1: The 12 Volt DC Power Supply

+12 Volts DC current with common ground is used to power all devices in the work cell. The power supply is connected a terminal strip that can be located anywhere on the table.



**Note:** The above unit (12 V Power Supply) and the Controller each have their own power supplies. Since there are multiple power supplies, one powering the device that produces a signal and the other apart of the device that accepts a signal they must have a common ground, a common reference between all power supplies.

**Students must verify the polarity of the power strip is correct before the start of the contest.**

## 13: Hardware Specifications - Sensor Box

---

### 13.1: Wiring

#### DO NOT OPEN SENSOR BOX

- The Sensor Box contains an Inductive Proximity Sensor and Micro-switch
- Terminal strip

Inductive Proximity (Prox) Sensor:

- + 12 Volts DC (Power for the Inductive Proximity Sensor)
- Ground (Common)
- SIG Output Signal

Limit Switch

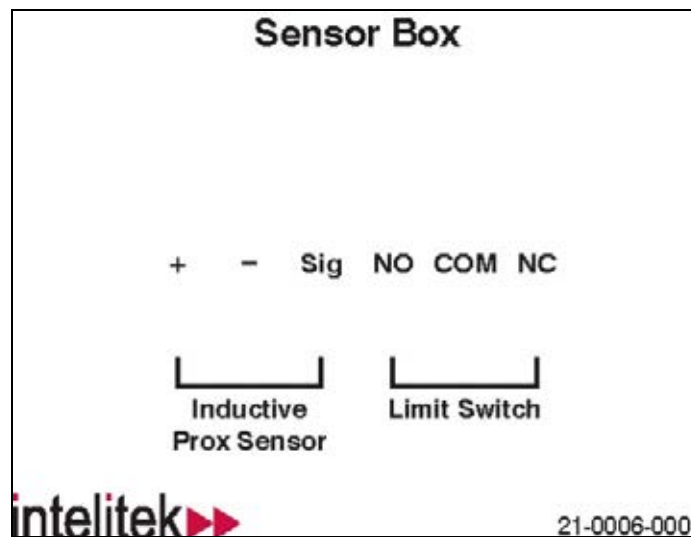
COM = Common, always connect to this, it is the moving part of the switch.

NC = Normally Closed, COM is connected to this when the switch is open (not pressed)

NO = Normally Open, COM is connected to this when the switch is closed (pressed)

#### DO NOT OPEN SENSOR BOX

If you have Questions, please ASK a contest official.





## 14: Hardware Specifications - Photo Sensor

---

### 14.1: Conveyor Sensor

Connect attached power supply to a 115 volt AC source.  
Connect the remaining leads to an Input and Ground on the I/O Interface.  
The leads are polarity sensitive.

#1 Connect to ground of the controller inputs

#2 Connection to a Robot Controller input (#1 through# 8)

With Power on the controller and the Photo Sensor connected, place hand in front of the Photo Sensor. The input should sense your hand in front of the Photo Sensor.



## 15: Hardware Specifications - Pneumatic Parts Feeder and Press

**CAUTION:** Never place your hand inside the parts feeder or press when the Air is connected.

### 15.1: Pneumatic Parts Feeder - Components

The parts feeder is an assembled device that consists of:

- Adjustable air regulator
- Double Acting cylinder with flow control valves
- Feeder Solenoid
- Feeder Switch – (Part-in-Stack detection sensor)
- Part “In Position for Pick-up” Switch
- Tubing
- Fittings

### 15.2: Pneumatic Parts Feeder - Theory of Operation

Air from the Feeder Solenoid Valve via the adjustable regulator is applied to the valve that is connected to the long cylinder. When 12 volts DC is applied to the “Feeder Solenoid” the valve is actuated causing the double acting cylinder to extend. The flow control valve controls the rate of extension. The removal of the 12-volt from the Feeder Solenoid valve allows the double acting cylinder to retract. The flow control valve controls the rate of retraction.

The “Feeder Switch” senses if a part is present in the feeder stack. “The Part In Position for Pick-up Switch” is for detecting if a part is present at the end of the feeder away from the stack , available for the Robot for part pickup.

NO = Normally Open  
NC = Normally Closed

#### Feeder Terminal Strip

Feeder Limit Switch			Part Present Limit Switch			Extend Reed Sensor	Retract Reed Sensor
NO	COM	NC	NO	COM	NC		

#### Solenoid Terminal Strip

+	-	+	-	+	-
Feeder Solenoid		Press Solenoid		Aux Solenoid	

### 15.3: Pneumatic Press with Sensors - Components

The press consists of:

- Double acting pneumatic cylinder
- Press Solenoid Valve
- Tubing
- Fittings

### 15.4: Pneumatic Press with Sensors - Theory of Operation

Air from the Press Solenoid Valve via the adjustable regulator is applied to the valve that is connected to the long cylinder. When 12 volts DC is applied to the "Press Solenoid", the valve is actuated causing the double acting cylinder to extend. The flow control valve controls the rate of extension. The removal of the 12-volts from the Press Solenoid, the valve allows the double acting cylinder to retract. The flow control valve controls the rate of retraction.

A Reed Sensor determines if the cylinder is extended or retracted. The Reed Sensor is a magnetic switch that closes when an internal portion of the cylinder is in close proximity to the switch. The flow control valves control the rate of extension and/or retraction of the cylinder.

NO = Normally Open

NC = Normally Closed

Reed Sensors provide a contact closure.

#### Feeder Terminal Strip

Feeder Limit Switch			Part Present Limit Switch			Extend Reed Sensor	Retract Reed Sensor
NO	COM	NC	NO	COM	NC		

#### Solenoid Terminal Strip

+	-	+	-	+	-
Feeder Solenoid		Press Solenoid		Aux Solenoid	

## 16: Specifications- Flow Chart

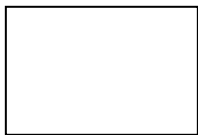
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### 16.1: Acceptable Symbols

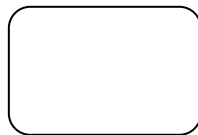
Quite often, when employed by a Company or a Corporation, anything that you produce belongs to them. The corporation owns the patents and copyrights. Therefore, complete documentation is quite essential. You may think that keeping the knowledge to yourself is job security but at some time in your career you could be the recipient of an undocumented system. In this situation you will want all the documentation you can find. Document your work completely.

1. The Flow Chart symbols you use, must be the symbols provided on this page. Straight lines should be drawn with a straight edge. The program must start with a Terminator symbol and then proceed through the various symbols that explain your program. Use arrow heads to indicate the direction of program flow. Continuations without lines must use Connectors with identifying characters such as (A, b, 1 or 2 etc.). Use these symbols to develop your Flow Chart.
2. The symbols are representative of the required shapes. You may change the size to meet your needs.
3. Use a straight edge to draw the symbols. Paper is available in the back cover of your notebook.
4. Be neat. If the judges can't read them they can't score them. Points lost.
5. Your Flow Chart and Robot Program must coincide. The Flow Chart/Robot Program scoring will be based on how well you designed your Flow Chart before you started developing your Robot Program.

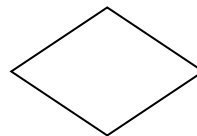
#### FLOW CHART SYMBOLS



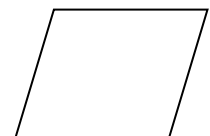
Process



Alternate  
Process



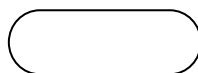
Decision



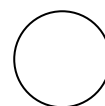
Data



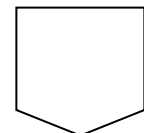
Predefined  
Process



Terminator



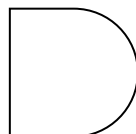
Connector



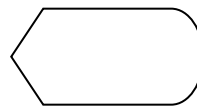
Off page  
Connector



Stored  
Data



Delay



Display

## 17: Specifications- Print to Screen

---

### 17.1: Command

The first line in your robot program MUST be a PrintToScreenLog command. And another PrintToScreenLog when your program reaches the point that it is looking for the next part and all of the parts have been processed. This will help in determining your run time! There may be other instances when the task requires the use of the PrintToScreenLog command

The following is a sample program to TEST the PrintToScreenLog command

1. Counting parts called: ITEM
2. Using a Variable named: NUMBER
3. Set Variable NUMBER = 0
5. LOOP:
6. Set Variable NUMBER = NUMBER + 1
7. Print to Screen & Log: ITEM= 'NUMBER'
8. Wait 25 (10ths of seconds)
9. If NUMBER<3 Jump to LOOP

Notes: If using a subroutine, they must be at the end of the program.  
Any remarks must be within the subroutine itself.

## 18: Specifications- Conveyor Control

---

### 18.1: Sample ER-4U SCORBASE Software program

In order for the conveyor to stop correctly, please use the following commands in your program.

```
Start Conveyor Axis 8 at Speed 5 in Plus Direction
Enable Input Interrupt 6
On Input Interrupt 6 On Call Subroutine STOP_CONVEYOR
Wait 100 (10ths of seconds)
.
.
Set Subroutine STOP_CONVEYOR
Stop Conveyor Axis 8
Return from Subroutine
```

### 18.2: Program and Subroutines

In this example:

- Positions 12 and 13 – Parts are above the conveyor
- Positions 2 and 3 – Parts are on the conveyor
- Photo Sensor is connected to input 6

Program example:

```
Remark: **** Place part on Conveyor ****
Go to Position 12 Speed 5
Go to Position 2 Speed 5
Open Gripper
Go to Position 12 Speed 5
Start Conveyor Axis 8 at Speed 5 in Plus Direction
Enable Input Interrupt 6
On Input Interrupt 6 On Call Subroutine STOP_CONVEYOR
Wait 100 (10ths of seconds)
.
. The rest of the main program
.
.
Remark: ***Subroutine's start here***
Set Subroutine STOP_CONVEYOR
Stop Conveyor Axis 8
Go to Position 13 Speed 5 Position 13 – part is above the conveyor
Go Linear to Position 3 Speed 5 Position 3 – part is above the conveyor
Close Gripper
Go Linear to Position 13 Speed 5
Return from Subroutine
```

**Notes:** All subroutines must be at the end of the program.  
Any remarks must be within the subroutine itself.

## Required Documentation - Safety Issues

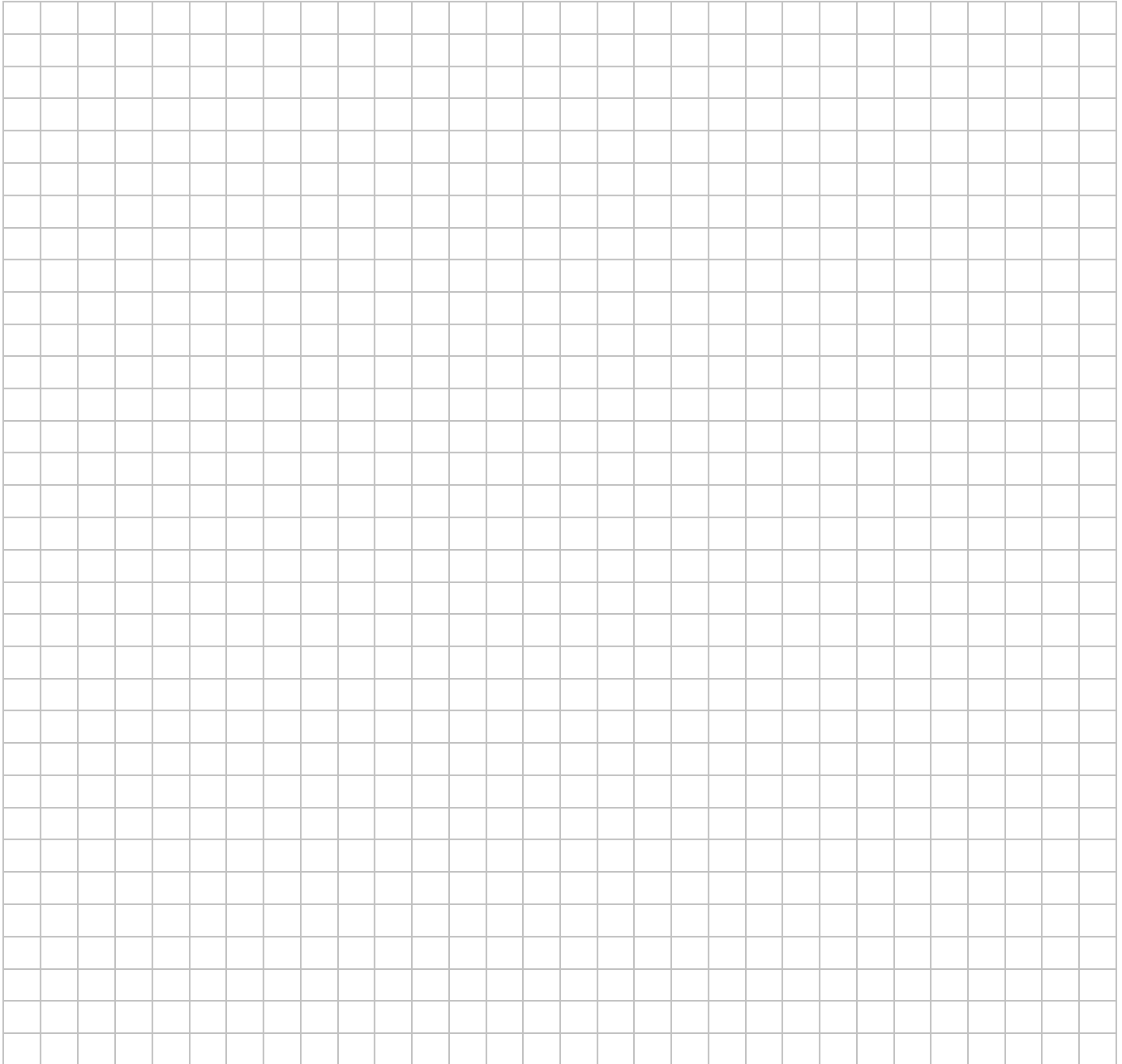
Describe any safety issues that are of concern when running the widget process.

This image shows a blank sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

## Required Documentation - FLOW CHART

Draw a flowchart of the Robot program. Use a straight edge. Be complete, neat and legible.

Total Points \_\_\_\_\_



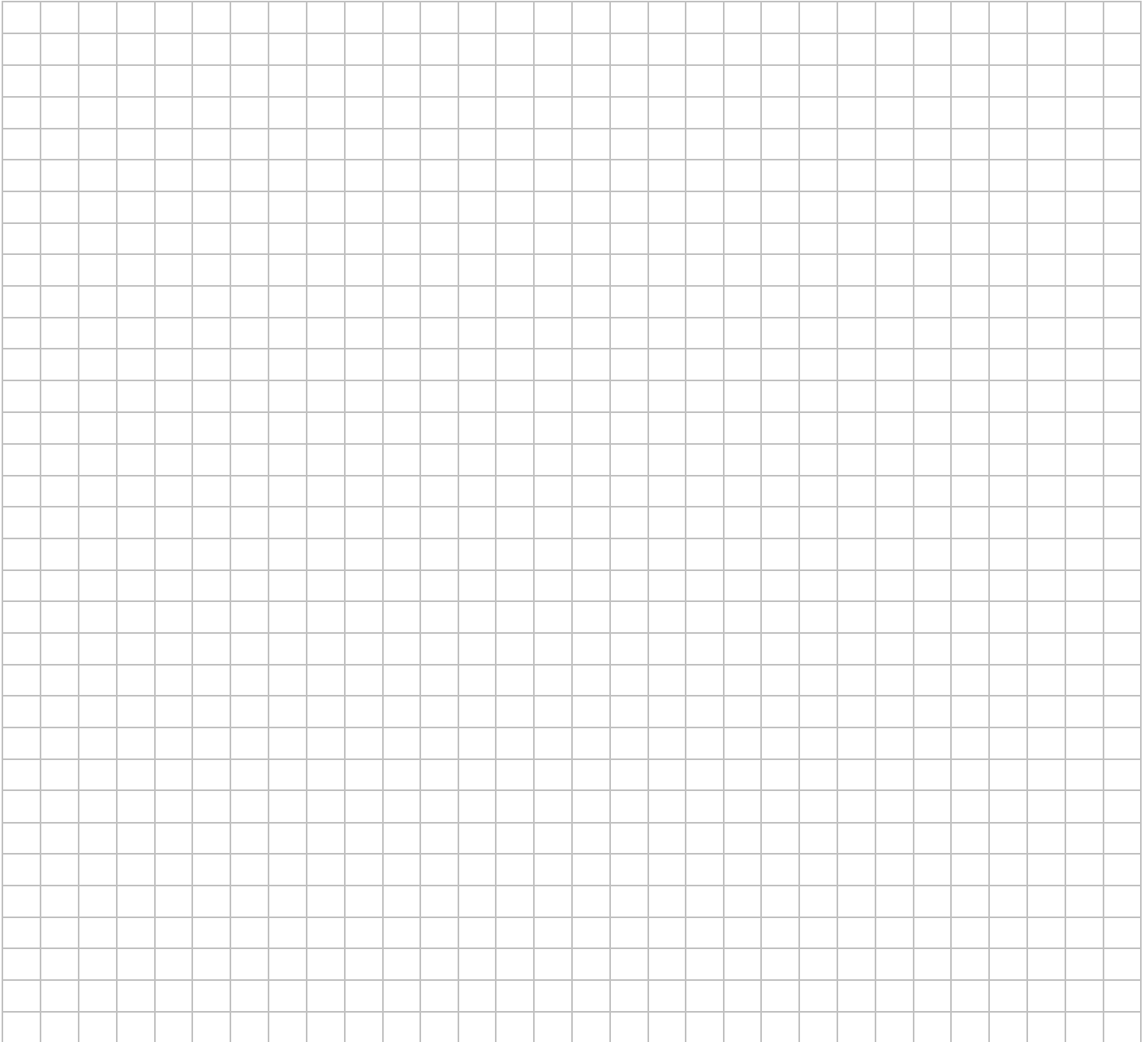
See judges or instructor for additional copies.



## Required Documentation – System Hardware Layout

Draw a sketch of the hardware layout of your system. Use a straight edge. Be complete, neat and legible.

Total Points \_\_\_\_\_



## Required Documentation – Controller Interface Input Assignments

Describe what is connected to each input on the controller interface. The judges must be able to read and understand what is connected to each input of the controller interface.

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_
4. \_\_\_\_\_
5. \_\_\_\_\_
6. \_\_\_\_\_
7. \_\_\_\_\_
8. \_\_\_\_\_

Notes: (Optional)

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---

## Required Documentation – Controller Interface Output Assignments

Describe what is connected to each output on the controller interface. The judges must be able to read and understand what is connected to each output of the controller interface. They should also be able to look at the device and see the wire color etc.

Output #1 COM _____	NO _____ NC _____
Output #2 COM _____	NO _____ NC _____
Output #3 COM _____	NO _____ NC _____
Output #4 COM _____	NO _____ NC _____
Output #5 COM _____	NO _____ NC _____
Output #6 COM _____	NO _____ NC _____
Output #7 COM _____	NO _____ NC _____
Output #8 COM _____	NO _____ NC _____

## Required Documentation - PLC Interface Input and Output Assignments

Describe what is connected to each input and output on the PLC. The judges must be able to read and understand what is connected to each input/output of the PLC. They should also be able to look at the device and see the wire color etc.

### Inputs:

1.

2.

3.

4.

5.

6.

7.

8.

### Outputs:

1.

2.

3.

4.

5.

6.

7.

8.

# Required Documentation – Device Terminal Strip Assignments

Describe what is connected to each device. The judges must be able to read and understand how each device is connected.

## Pneumatic Parts Feeder Pneumatic Press

### Feeder Terminal Strip

#### *Feeder Limit Switch*

NO	_____
COM	_____
NC	_____

#### *Part Present Limit Switch*

NO	_____
COM	_____
NC	_____

#### *Extended Reed Sensor*

Top	_____
Bottom	_____

#### *Retracted Reed Sensor*

Top	_____
Bottom	_____

### Solenoid Terminal Strip

#### *Feeder Solenoid*

+	_____
-	_____

#### *Press Solenoid*

+	_____
-	_____

#### *Aux Solenoid*

+	Not Used	_____
-	Not Used	_____

## Required Documentation – Device Terminal Strip Assignments Continued

Describe what is connected to each device. The judges must be able to read and understand what is connected to each device.

### *Stack Light*

COM

Red

Yellow

Green

Blue

### *Sensor Box - Inductive Prox Sensor*

+

-

Sig

### *Limit Switch*

NO

COM

NC

Notes: (Optional)

---

---

---

---

## Required Documentation – Robot Positions

Document each position used for each device as part of the robot program. (Required)

Location	Part Feeder	Part Press	Sensor Box – Prox Sensor	Sensor Box Micro Switch		Part Template Good Metal 1	Part Template Good Metal 2	Part Template Good Metal 1	Part Template Good Plastic 1	Part Template Good Plastic 2	Slide Base
Pick Position											
Above Pick Position											

Other positions that you feel would help a technician trouble shoot this Robotic workcell. (Optional)

Location											
Pick Position											
Above Pick Position											
Other											

Notes: (Optional)

---



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---



---

# Task 1

## Proposal / Design Stage

No Power Cord  
No Wiring

# Task 1

## Implementation Stage

Power Cord after initial wiring inspection

# Task 2

## Proposal / Design Stage

No Power Cord  
No Wiring

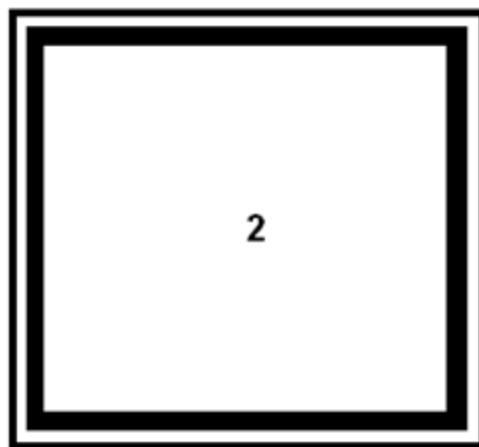
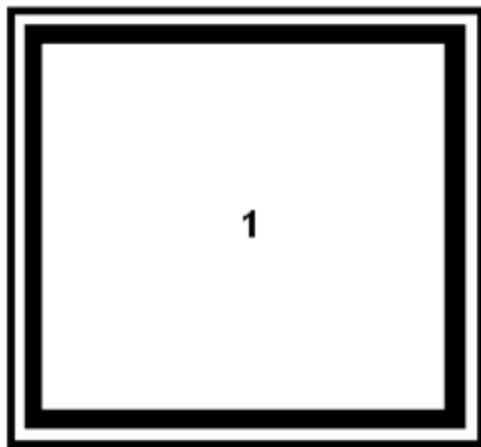
# Task 2

## Implementation Stage

Power Cord after initial wiring inspection



### Plastic Parts

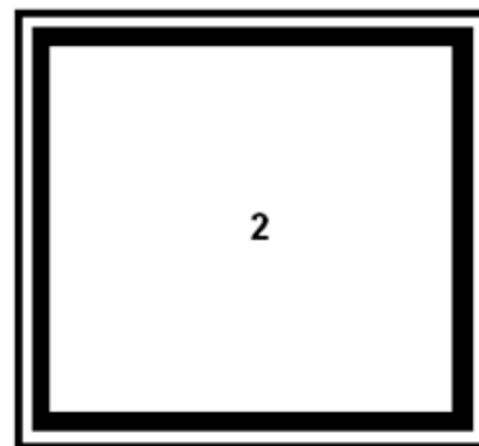
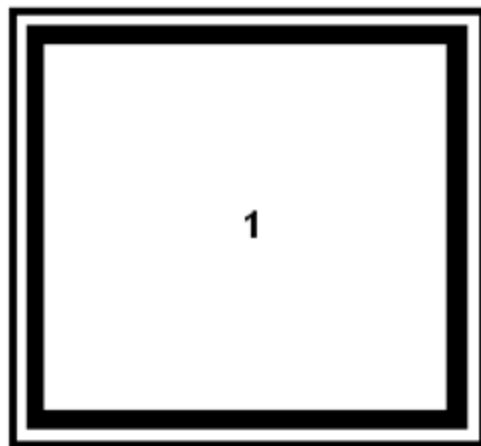


All Parts must fit inside each bin.

*Intelitek - Skills USA Competition*

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### Metal Parts



All Parts must fit inside each bin.

*Intelitek - Skills USA Competition*

**Scorbot Robotics, Inc. Storage Template**

**1**

**2**

All Parts must fit inside each bin.

*Intelitek - Skills USA Competition*

**Scorbot Robotics, Inc. Storage Template**

**1**

**2**

All Parts must fit inside each bin.

*Intelitek - Skills USA Competition*