Hatters Robotics 2021
Team Manual v1.1

2021 Hatboro-Horsham HS Robotics

Intramural Challenge

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In preparation for our Intramural Challenge and the FIRST @ HOME Challenges there has been a considerable amount of work to plan a safe and fun atmosphere in which we can host an internal robotics competition. This document works to form a safe and conducive working atmosphere for our student and adult team members. The precautions in this document are supplemental to the district's COVID-19 precautions.

1. COVID-19 Precautions

1.1. Social Distancing

- Team members will maintain social distancing within the build space
- A maximum of **8** people may occupy the build space at a time.
- Team are encouraged to work virtually whenever possible
  - Design Meetings, Project Planning, Business Meetings, etc can be conducted virtually.
  - In person meetings are primarily reserved for robot build/construction or FIRST@Home Challenge robot work.
- No team member will be excluded from a In-person team meeting if they cannot attend. We will utilize a Microsoft Teams telepresence unit for individuals who can not attend a meeting in person.

1.2. Face Coverings

- Face Coverings are always required when in the building.
- ***A face covering may be removed to take a drink or eat, this is the only exception to the face covering requirement.***

1.3. NO Sharing

- As much as we love to share with our teammates all snacks/drinks/food must be individually wrapped and only consumed by the intended individual.
- Students should be prepared with their own water bottle, any snacks/food they will need for a meeting. A separate designated space will be provided just outside the build space for an individual to take a food or beverage break.
- Each team member will be issued a pair of safety glasses. There cannot be a shared pool of glasses. Disinfecting supplies will be readily available.

1.4. Build Space Cleaning and Disinfection

- The last 30 minutes of any team meeting will be dedicated to the cleaning and disinfection of workspaces and tools.
- The first in-person meeting for each team, members will receive instruction for cleaning and disinfecting surfaces within the Build Space.
- Surfaces will be disinfected with 70% isopropyl alcohol and following CDC Guidelines.
- Shared Tools and Machines will also be disinfected
- Tools **may not** be placed back in the tool chest until after being disinfected. There will be a cart to place tools on and they should be disinfected at the end of the meeting.

1.5. COVID-19 Screening

- Team Members (Students / Adults) must complete the Hatboro-Horsham COVID-19 Screening form prior to arrival for each meeting:
  Hatboro Horsham Athletic Department and Extra Curricular COVID-19 Screening (office.com)
- Team Members will need to have their temperature checked and logged as they enter the building for a team meeting
- Team members should try to arrive at the same time, so screening can be done efficiently and safely.

2. Program Participation Requirements

2.1. Academic Eligibility

Must maintain a minimum of a C to continue participation
Students are encouraged to seek help from mentors and other students
Complete homework and assignments prior to robotics meetings
Grades will be checked periodically

2.2. Team Covenants

Respect
Yourself, Teammates, Mentors, Parents, Opponents, Volunteers
Communicate
Clear, Open and Honest communication
Accountability and Responsibility
For you actions and other's
Focus
Meaningful and Complete Work
Motivation
Willing to Learn, Willing to Teach
Attitude
Respond, Don't React
Fun
Why else are you here?

2.3. Gracious Professionalism ©

With Gracious Professionalism, fierce competition and mutual gain are not separate notions. Gracious professionals learn and compete like crazy but treat one another with respect and kindness in the process. They avoid treating anyone like losers. No chest thumping tough talk, but no sticky-sweet platitudes either. Knowledge, competition, and empathy are comfortably blended. Dr. Woodie Flowers, FIRST National Advisor and Pappalardo Professor Emeritus of Mechanical Engineering, Massachusetts Institute of Technology, coined the term "Gracious Professionalism™." Gracious Professionalism is part of the ethos of FIRST. It's a way of doing things that encourages high quality work, emphasizes the value of others, and respects individuals and the community. With Gracious Professionalism, fierce competition and mutual gain are not separate notions. Gracious professionals learn and compete like crazy but treat one another with respect and kindness in the process. They avoid treating anyone like losers. No chest thumping tough talk, but no sticky-sweet platitudes either. Knowledge, competition, and empathy are comfortably blended. In the long run, Gracious Professionalism is part of pursuing a meaningful life. One can add to society and enjoy the satisfaction of knowing one has acted with integrity and sensitivity.

How does this apply to our team?
With the use of our team covenants, Gracious Professionalism is made a focal point for how we act towards not only other teams and volunteers, but our teammates. Gracious professionalism is a defining characteristic of our team because through our team covenants, we exemplify Gracious Professionalism.

3. Intramural Challenge Admin Manual

With the immediate lack of a competitive physical FRC season the mentors have designed a robotics challenge that can be completed by smaller teams, utilizing our limited space and simulating a real-world design challenge. With limited time and resources your team will need to plan and meet milestones to achieve your goals.

3.1. The Teams

- Each team is comprised of student and adult members
  - 4-5 students per team
  - 1 adult mentor per team
  - For the purposes of forming the team six student leads will be chosen by the mentors.
  - Teams will be formed using a "Torney" Draft Order Algorithm
    - This Algorithm is used to create a fair draft order where picks are evenly distributed among pickers as close as possible to a mathematical ideal.
    - After the fair order draft, each picker will be able to trade 1 individual with another team.
  - After the draft rounds, mentors will be assigned to a team by choosing a number from a hat.
  - After the initial teams are formed, the student and adult team members can work on their own leadership structure and decision-making matrix or procedure.
  - Post draft, each team can recruit one additional member to their team that was not in the draft allocation.
- "**Specialist" mentors** – additional technical support that can be brought in for a meeting
  - A specialist mentor is a non-team member brought in for specific team support
    - Business Plan Support
    - Electronics Support
    - Video Production Support
    - Software Support
    - Mechanical Support
  - One Specialist mentor may attend a meeting at a time
  - Each Team will receive 7 specialist mentor coupons
  - Teams will schedule a specialist mentor at least one week in advance of the meeting and must communicate with the specialist mentor and confirm their availability prior to scheduling the build space.
  - Specialist Mentors will likely also have a team of their own.
  - A meeting held by a specialist mentor for the advancement of all teams will be excluded from the ticket requirement
  - Questions to any mentor are encouraged, however if the work required by said mentor is greater than 30 minutes the team may be charged a specialist coupon, unless said team posts

Pick Number	Picker
1	HR 3
2	HR 2
3	HR 5
4	HR 6
5	HR 1
6	HR 4
7	HR 4
8	HR 1
9	HR 6
10	HR 5
11	HR 2
12	HR 3
13	HR 1
14	HR 2
15	HR 5
16	HR 6
17	HR 4
18	HR 3
19	HR 3
20	HR 4
21	HR 6
22	HR 5
23	HR 2
24	HR 1

the work effort publicly for all teams to utilize. This must be posted in the "Public Team Posts" in the IC Coordination team by the team lead to qualify for exemption.

- **"Open" Mentors** – mentors who may be accessed by a team for specific support
  - The following mentors are "Open" Mentors and can be utilized by teams upon scheduling a meeting with the mentor:
    - John Piergallini, Sr. | Susan Piergallini | John Piergallini, Jr.

3.2. The Schedule

3.2.1. Limitations

- No more than **8** individuals can occupy the build space at a time.
    - Build Space is limited to the Robotics Room (F-125) at the High School
    - Student Team Members may virtually participate from home utilizing the Telepresence Unit in the Build Space
    - 1 Adult Mentor
    - 1 Specialist Mentor
    - Up to 6 Student Team Members

3.2.2. Remote meetings

- Teams will be encouraged and expected to have remote meetings via Microsoft Teams
- Design work, planning, software development, etc. should be worked on remotely
- No limit on remote meeting time in each week. Meeting times must be a consensus of team members. All team members must be invited to all meetings.

3.2.3. In-person meetings

- In-person meetings for the Intramural Challenge are separate from in-person meetings for FIRST@Home.
    - *FIRST@Home In-person meetings will still follow all COVID-19 Precautions.*
- Teams will submit a work-plan proposal for their In-Person Scheduled Meetings to their Team Mentor.
- Acceptable activities for in person meetings include: Prototyping, Part Fabrication, Assembly, and testing. Meeting in-person for discussions without the need for physical use of space or tools is prohibited.
- The team mentor **MUST** be available for the scheduled meeting time
- In-Person Meeting Times will be restricted to:
    - 4:00 pm to 9:00 pm Monday through Friday (4 hours maximum)
    - 10:00 am to 6:00 pm Saturday and Sundays (6 hours maximum)
    - *If a different schedule is needed by a team for a meeting it can be flexible, however no weeknight meeting may exceed 4 hours, and no weekend meeting may exceed 6 hours.*
    - *In-person meetings may not be scheduled prior to **March 1, 2021***
- Meetings will need to be scheduled based on availability. Each team is not guaranteed a day in the shop every week, so teams should be prepared when they receive their shop night to get physical work completed.
- Teams may only schedule **One** In-person meeting in a rolling two-week period.
    - *When COVID-19 restrictions are no-longer a factor the one in-person meeting every two weeks will be re-visited or reformulated.*

3.2.4. Weekend meetings

- Weekend meetings will become available when a design has been completed, and the need for a longer production meeting is clear to the adult mentor. These meetings will be scheduled on a first come, first serve basis, but each team will be afforded no more than 4 Weekend dates through June 2021.

3.2.5. Scheduling In-Person Meetings

- A common calendar will be created for room and mentor scheduling. One individual from each team will be responsible for scheduling the build space for their team. This individual is also responsible for contacting mentors for availability.

3.3. Team Updates

Should the necessity arise, Team Updates will provide additional clarification of rules and regulations. If needed they will be posted in the Hatters Robotics Team on Tuesday Evenings.

3.4. Questions and Answers

In the event of questions about rules and regulations, the Team Lead shall ask questions in the Team Lead Coordination Q&A Channel. Should additional clarification from a question be required it will be issued in a Team Update.

3.5. Budget Constraints

Budgets are an essential part of any project. To ensure that each team has the resources required to build a competitive robot each team can earn additional funding for their robot by meeting objectives and/or winning awards. Teams will need to manage their own budget when designing and fabricating their robot.

- Each team will start with a budget of **$750.00** at the start of the season
- Teams should identify an individual to maintain an accurate representation of the team's budget throughout the challenge.
- Opportunities to receive additional funds added to the budget will be available as the season progresses.
  - Teams will be awarded additional funding for meeting the following objectives:
    - **Completed and mentor approved team style standards/imagery plan $ 50**
      - *Cannot be the standard "Hatters Robotics" style standard*
      - *Must include an appropriate team name and logo that conforms with Hatboro-Horsham or Hatters, but does not need to follow school colors*
      - *Example can be found at http://www.team708.org/media*
    - **Completed and mentor approved team organization plan $ 50**
      - *Team Organization chart must include a role for each student member*
      - *Job/Role Descriptions must accompany the organization chart*
    - **Completed and mentor approved project plan $ 50**
      - *Project plan must include at least 4 milestones*
      - *Project plan must include dates and resources allocations*
    - **Video update of your team progress $ 20 per video**
      - *Must be at least 2:00 min and include significant updates*
        - *Music is permitted, but must not be blocked when uploaded to YouTube. Additional information will be provided for this requirement.*
      - *Can only be awarded this objective 5 times for a maximum of* **$100**
    - **Completed and mentor approved software framework $ 75**
      - *Must identify and document the foundations and conventions that will be followed for software development*
      - *Must detail which repository will be utilized by the team*

- **Completed and mentor approved robot design** **$100**
  - *CAD Design or Hand Draft Drawings are required*
  - *Electrical and signal wiring design must be included*
- **Meet or Exceed a Major Milestone** **$ 20**
  - Must be a major milestone identified in the project plan
  - *Can only be awarded this objective 4 times for a maximum of* **$ 80**

- Team mentor and one other mentor must agree that the team met the objective for the objective or milestone to be awarded.
- Please see the chart below for the maximum budget value that each team can achieve based on the starting budget and achieving objective:

Starting Budget	$ 750.00
Objective	
Completed and mentor approved team style standards/imagery plan	$ 50.00
Completed and mentor approved team organization plan	$ 50.00
Completed and mentor approved project plan	$ 50.00
Video update of team progress ($20 / video)	$ 100.00
Completed and mentor approved software framework	$ 75.00
Completed and mentor approved robot design	$ 100.00
Meet or exceed a milestone ($20 / milestone)	$ 80.00
	$ 1,255.00

- Items included in the Kit of Parts do not count towards the robot cost accounting, only in the quantities in which they were provided. These items must be listed, but when it is a kit of parts item list "1" in the KOP Column and it will exclude it from the Cost Accounting.
- All physical items on the robot must be accounted for in the cost of the robot including nuts, bolts, fittings, wire, etc.
  - This includes any materials or components within the shop and not specifically ordered for a team.
  - Teams may opt to include the minimum purchasable quantity of items in the budget, i.e a box of bolts **or** account for the per unit cost of the number of bolts.

If a box of 100 bolts cost $5.00 the team can account for $5.00 on the Cost Accounting worksheet, or if the team used 60 of the bolts and each bolt cost $.05 they would account for $3.00

  - All conducting power must be accounted for in the bill of materials.
    - 12 Gauge – 18 Gauge is calculated at $1.00 per linear foot of length
    - Battery Cable (6 Gauge) is calculated at $3.00 per linear foot of length
    - Signal Cables (PWM) or (20-28 Gauge Wire) can be calculated at purchase price or if assembled at $0.25 per foot.
    - Power and signal connectors must be accounted for in the team's budget.
  - 3D Printed Items must be accounted for based on the time it takes to print the piece. The listed rate is $ 5.00 per hour of machine time. The program will purchase the

necessary spools of filament, teams are only required to calculate machine time in this scenario.

If a part takes 45 minutes to print the calculation would be:
45/60 = .75 x $ 5.00 = $ 3.75

- Materials consumed in prototyping must be accounted for in either the robot budget or from sponsorships acquired. Any substantial change to the usability of the material is considered consumed

Team A uses a single 6-foot piece of aluminum tubing. They make three cuts to the material, and drill holes to accommodate their design. The unit price of that material is $57.00. Team A must account for the material in the Robot or Supplemental Budgets.

- Sponsorships can be acquired for non-robot costs, not to exceed **$250.00** per donation. Expenditures that apply to any sponsorship must be provided in a supplemental budget document.

Sponsorship or budget money can be used for team apparel, prototyping costs, or other incidental team costs associated with imagery or other team activity. Approval of sponsorships must include the team mentor, and Mr. Zygmont.

3.6. Awards

Teams will have the opportunity to submit and win awards at different time points throughout the season. Awards will have a monetary value associated with them that will be awarded to a team's budget for use throughout the season. Awards are broken down into three value categories:

Award Tier	Budget Value
Bronze	$25
Platinum	$50
Gold	$100

3.6.1. Non-Engineering Based Awards

3.6.1.1. Business Plan

- Award Tier: Bronze
- To be successful on a project, it takes careful planning and execution. This award will be given to the team(s) that provide and explain their plan for a successful season. Things to consider when creating your plan include how you manage your budget, timelines and resources.
- Business Plans must include a budget, SWOT Analysis, Organization Structure and Project Plan
- This award will be awarded after each individual team submits their business plan that meets all requirements and has been approved by their team mentor and one other mentor.

3.6.1.2. Top Executive Award

- Award Tier: Gold, Platinum, Bronze
- This award will be awarded to teams that best demonstrate a sound business plan and is able to execute their plan without deviations.
- This award will be awarded after 1 competition has occurred.

3.6.1.3. Imagery Award

- Award Tier: Gold, Platinum, Bronze
- This award will awarded to teams that best demonstrate visual aesthetic integration across their robot and team.
- This award will be awarded after 2 competitions have occurred.

3.6.1.4. Team Video Award

- Award Tier: Gold, Platinum, Bronze
- This award will be awarded to teams that produce the best overall team video. Video should include footage across not just meetings, but robot performance as well.
- This award will be awarded after 2 competitions have occurred.

3.6.2. Engineering Based Awards

3.6.2.1. Design Plan

- Award Tier: Bronze

- To build and program a robot takes detailed planning to make sure you are able to build a robot that fits within the constraints. Teams who complete a Design Plan must include drawings (both mechanical and electrical).
- This award will be awarded after each individual team submits their design plan that meets all requirements and has been approved by their team mentor and one other mentor.

3.6.2.2. Designer's Award

- Award Tier: Gold, Platinum, Bronze
- This award will be given to the teams that best showcase design detail in their robot drawings.
- This award will be awarded after 2 competitions have occurred.

3.6.2.3. Engineering Excellence Award

- Award Tier: Gold, Platinum, Bronze
- This award will be given to the teams that had a design and were able to successfully execute that design during the competition.
- This award will be awarded after 2 competitions have occurred.

3.6.2.4. Creativity Award

- Award Tier: Gold, Platinum, Bronze
- This award will be given to the teams that came up with a creative and unique design, part or concept. Teams must be able to explain how they came up with the creative component and how it is advantageous for their robot.
- This award will be awarded after 2 competitions have occurred.

3.6.2.5. Competition Winner

- Award Tier: Platinum
- This award will be given after each competition to the team who achieves the highest score.

3.6.2.6. Top Climber

- Award Tier: Platinum
- This award will be given after each competition to the team whose robot is able to reach the highest height

3.6.2.7. Top Baller Award

- Award Tier: Platinum
- This award will be given after each competition to the team whose robot is able to release the most additional tumbleweed during a match.

3.6.3. Tumbleweed Takeover Challenge Awards

3.6.3.1. Champion

- Will be given to the team who has the highest cumulative total score after all competitions have been completed.

3.6.3.2. Finalist

- Will be given to the team who has the second highest cumulative total score after all competitions have been completed.

4. Challenge: Tumbleweed Takeover

4.1. Challenge Summary

Traveling through the wild west, your group of RANCHERS are working to save a TUMBLEWEED overrun TOWN and find a SAND DUNE to eradicate the TUMBLEWEED.

ROBOTS collect foam footballs (called TUMBLEWEED) and transport them up a flight of stairs (called the SAND DUNE) to score points based on the elevation of each TUMBLEWEED and ROBOT at the end of the MATCH. Additional TUMBLEWEEDS are released by shooting through a target known as the LASSO.

4.2. The Arena

- The Arena is any stairwell within Hatboro-Horsham HS. The stairwell is known as the SAND DUNE.
- The starting surface the ROBOTS start is known as the TOWN.
- Each COMPETITION will be a different stairwell that will be randomly selected the day of the COMPETITION. Different teams may compete on different stairwells, however the stair complexity and style will be the same.

  Any stairwell means any stairwell that is accessible to you (main office is excluded). Take the time to explore the school, any could be chosen. There are four types of stairs:

  - Stairs with rectangular handrail
  - Stairs with circular handrail
  - Back of stage stair
  - Miscellaneous stair without consistent handrails such as the auditorium balcony or gym bleachers. Note that this final category will only be selected as a bonus round or final design challenge.
- The LASSO is a target used to shoot or place TUMBLEWEED through. The LASSO is comprised of a ¾" thick hoop with inside diameter of 29¾" (+/-1") and the bottom of the hoop is 48" tall (+/-1"). It is supported with two vertical stands on each side of the disc and legs that extend outwards. There is a horizontal support that connects the base of the legs.
  - The LASSO is placed on a stair landing (called the MESA), the level above (called the PLATEAU), or TOWN. The starting position of the LASSO is random and determined at the start of the COMPETITION and will be the same for all MATCHES in the COMPETITION.

Figure 1

The LASSO is not fixed to the ground and can be moved by the ROBOT. If the LASSO falls over or falls down a set of stairs, it is considered out of play and no additional TUMBLEWEED can pass through.

4.3. Match Play

- The scoring element is a 9.5” long foam football called the TUMBLEWEED. TUMBLEWEEDS are manufactured by either POOF or Hedstrom. The color of the TUMBLEWEEDS vary.

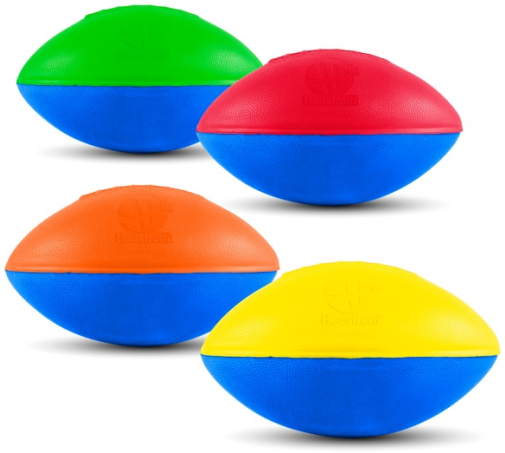

Figure 2

> Each team will be provided TUMBLEWEEDS for use in testing. Please keep team balls segregated.

- RANCHERS remotely operate the ROBOTS for the entirety of the MATCH.
- ROBOTS may carry/support/hold/hoard/push a maximum of 3 TUMBLEWEEDS at any given time.
    - Violation: Discard any additional TUMBLEWEED as soon as it is picked up and there is no penalty. If the ROBOT performs a function not intended to discard a TUMBLEWEED (i.e. climb stairs, shoot through LASSO, etc.) points for the additional TUMBLEWEED will not be scored. The lowest scored TUMBLEWEED will be voided.
- The length of the MATCH is 5 minutes.

> The length of the match may be adjusted as the season progresses.

- MATCH Start:
    - ROBOT starts fully supported on the TOWN not touching the SAND DUNE or railing
    - 4 TUMBLEWEEDS are available at the start of the MATCH. ROBOT may start with up to 2 TUMBLEWEEDS touching or fully supported by the ROBOT. Remaining TUMBLEWEEDS are placed in the TOWN by the team not touching the ROBOT, SANDDUNE, or LASSO.
- Each TUMBLEWEED that passes through the front of the LASSO releases one additional TUMBLEWEED. Up to 6 additional TUMBLEWEED can be obtained in the MATCH. The ROBOT must release control of the TUMBLEWEED when the TUMBLEWEED passes through the LASSO.
    - Additional TUMBLEWEED are released into the TOWN.

> TUMBLEWEED are dropped in by a mentor / referee who may aim as desired (I.e. may be dropped from the stair above).

- At the conclusion of the MATCH, RANCHER must stop controls and put down the controller. Do not touch the robot or TUMBLEWEED prior to scoring.
- TUMBLEWEED that become inaccessible or leave the ARENA are not scored and are not returned to play during the MATCH.

> If a TUMBLEWEED becomes lodged in a light fixture or other building element, it is considered out of play. Teams should be sure to design the ROBOT to fully control the game elements and not damage the school.

- TUMBLEWEED that are damaged remain in play for the entirety of the match and are not replaced. If a TUMBLEWEED is torn in half during a MATCH, the larger portion that remains is what is scored.
    - Teams may not intentionally damage the TUMBLEWEED. Robots must pass a safety inspection by the referee/lead mentors that the ROBOT will not intentionally damage the game elements.

4.4. Scoring

- All scoring is at the end of the match when all TUMBLEWEED/ROBOT come to rest or 10 seconds after time expires.
- TUMBLEWEED:
    - 1 point per TUMBLEWEED for each linear foot above the TOWN.
        - TUMBLEWEED scoring is relative to its highest point at rest and rounded up to an integer.
        - TUMBLEWEED score cannot be negative.

- If the top of the TUMBLEWEED is 10.1 feet above the TOWN, the score is 11 points
- The height of the second level is roughly 15.5 feet
- Note there is no maximum point value. TUMBLEWEED may be higher than the floor above (I.e. the TUMBLEWEED may be raised 5 feet above the second floor summing to 15 + 5)

- ROBOTS:
  - Height Points:
    - 3 points for each linear foot the highest point of the robot is relative to the TOWN and rounded up to an integer.
    - ROBOT scores cannot be negative.

    - ROBOT points are multiple of 3. If the top of the ROBOT is 4.2 feet, the points are 15.
  - Additional Points:
    - 20 points for not touching the TOWN
    - 20 points for being fully supported by a stair tread and not touching the TOWN, railing, or guardrail
    - 30 points for being fully supported by a MESA or PLATEAU and not touching a stair tread, railing, or guardrail

    - Additional Points are additive. For example:
    - A ROBOT that is fully support by a stair tread and not touching the railing scores 40 points
    - A ROBOT that is fully supported by a MESA or PLATEAU and not touching a stair tread or railing scores 50 points.
- At each COMPETITION, teams will have a set number of MATCHES. The number will be adjusted per COMPETITION. The best score will be the final score for the team.

4.5. Robot

- Starting Configuration: 96” perimeter x 3’ tall. After the start of the match, there is no limit to the size of the extension.
- Weight: No limit
- ROBOTS may not intentionally detach or leave parts in the ARENA.
  - Violation: If egregious or beneficial to the score, the score will not count.

4.6. Human Interaction

- One RANCHER is permitted into the ARENA to view and control the robot. The RANCHER may not touch or interact with the TUMBLEWEEDS or ROBOT during the match. The RANCHER may walk through the ARENA throughout the MATCH or control from one location.

  The intent for this rule is to allow adequate sightlines to control the ROBOT without interfering with ROBOT play.

  - Penalty: A TUMBLEWEED that makes contact with the RANCHER will not be scored.
  - Penalty: A ROBOT that makes contact with the RANCHER will end the MATCH and all scoring is voided. Teams may not strategically end a MATCH.
- Additional RANCHERS may observe as allowed by social distancing at the time of the COMPETITION.
  - Video recording and photography is encouraged by the RANCHERS however no video replay will be viewed by the referee.

4.7. Competitions

- COMPETITION schedule is based on the progress of the teams. The date of the first COMPETITON will be updated in the manual, however assume the first COMPETITION will be in the early May time frame.

4.8. Safety & Damage Prevention

- Dangerous ROBOTS are not allowed
- Do not damage the school
- See 2021 Infinite Recharge Game Manual for additional safety requirements for ROBOT (pneumatic, electrical, etc.)

> Team mentor must sign off that ROBOT is safe and will not damage the school prior to any COMPETITION or practice.

4.9. Tumbleweed Takeover Glossary

- COMPETITION: An event in which a SAND DUNE is selected to run MATCHES.
- LASSO: Moveable target used to shoot or place TUMBLEWEED.
- MATCH: A five (5) minute period in which RANCHERS play Tumbleweed Takeover.
- MESA: A stair landing or mid-level landing that is not the highest surface of the stair.
- PLATEAU: The highest level of the stair.
- RANCHER: ROBOT driver. Only one RANCHER per team.
- ROBOT: Anything physically attached to the control system. Any portion of the ROBOT that becomes separated from the ROBOT is no longer considered the ROBOT.
- SAND DUNE: A given stairwell selected for COMPETITION.
- TOWN: The surface / plane of the floor that the ROBOT starts as identified by each COMPETITION.
- TUMBLEWEED: 9.5” long foam football scoring element.

5. Robot Build

Every team has been provided a basic control system. The control system takes inputs from the driver and translates them into actions the robot performs. A list of items included in the kit are shown below.

5.1. What's in the kit?

Name	Vendor	Part Number	Quantity
Gorgon Flex Basics Controls Bundle	AndyMark	am-4063	1
Logitech Gamepad F310	AndyMark	am-2064	2
Arduino Programming Cable	AndyMark	am-2416	1
Gorgon Flex and Ethernet Robot Controller	AndyMark	am-2900	1
18 Gauge Wire	AndyMark	am-3082_wire	5 Ft.
0M5P Radio Basics Control Bundle	AndyMark	am-4065	1
Open Mesh 0M5P	AndyMark	am-3205	1
18 AWG Ferrule	AndyMark	am-3738_18	2
Passive PoE Injector	AndyMark	am-3766	1
5 Ft Ethernet	AndyMark	am-3845	1
Spark Brushed DC Motor Controller	AndyMark	am-4260	4
CIM Motor	AndyMark	am-0255	2
Five Channel Line Following Sensor	AndyMark	am-4341	1
Ultrasonic Distance Sensor	AndyMark	am-4342	1
SPARK Brushed DC Motor Controller	AndyMark	am-4260	4
Ultrasonic proximity sensor EZ0 MB1200 MaxBotix	AndyMark	am-2435	1
Sensor 6PAK	AndyMark	am-3220	1
Hall Effect Latch	AndyMark	DRV5013	1
Hall Effect Uni-Polar Switch	AndyMark	DRV5023	1
Hall Effect Omni-Polar Switch	AndyMark	DRV5033	1
Hall Effect Analog	AndyMark	DRV5053	1
Optical Threshold	AndyMark	OPT101	1
Optical Analog	AndyMark	OPT101	1
Eaton Bussmann CB285-100 Circuit Breaker	Powerwerx	CB285-100	1
Blue Sea 5026 12 Circuit Fuse Block (PDP)	Powerwerx	5026-BSS	1
30 Amp Snap Action Breaker	AndyMark	am-0290	5
Noninsulated Ring Terminals NO 8 Screw, 16-14AWG	McMaster	7113K38	2
Noninsulated Ring Terminals NO 8 Screw, 12-10AWG	McMaster	7113K37	2

In addition to the items listed in the table above all teams will have access to a collective pool of sealed lead acid batteries. Specifically the 18 AMP hour batteries traditionally used in the FIRST ROBOTICS COMPETITION.

5.2. Overview

The kit is a basic platform to get a robot functioning. Any component of the kit *may* be swapped out at the expense of the team and by the approval of a mentor. Reasonable explanation of the change must be conveyed to the mentor.

5.3. Kit Details

The kit consists of four parts: the driver station, controller, input/output (IO), and power management.
The driver station is how an operator interfaces with the robot. Joysticks are used to take an operator's inputs. A computer takes the signals from the joysticks and sends them to the robot via WiFi for processing.
The controller, or "brain", of the system is the Gorgon Flex Robot Controller. This controller takes in data from the driver's station and sensors, executes code, and commands the motors and actuators to move. Joystick buttons are mapped to commands and executed when pressed. The commands are lines of code that result in a set of actions the robot can perform. This could be something like drive straight 5 feet or rotate the arm at a rate of 1 degree per second.

> For information on how to setup and use the control system please visit the link below:
> http://www.team221.com/robotopen/gs.html

Input/Output (IO) is where code meets the real world. Inputs are information that goes into the controller such a sensors or devices that sense the world. Sensors include devices such as switches, distance sensors, encoders, and potentiometers. Output are signals send out of the controller. Typically, in robotics these are used to control more powerful devices such as actuators. Some examples of actuators are relays, motors, servos, and solenoids for air powered devices.
For electrical devices like the controller and motors to function they require electrical power. The power management part generates and distributes the power for these devices. The battery supplies the power and the fuse block (PDP) with snap action breakers protects and distributes the power to the separate devices.

5.4. Motors & Actuators

R1. Teams are permitted to specify any 12-volt brushed motor with a purchase value of less than $ 50.00

> Given the extensive amount of motors allowed on the ROBOT, teams are encouraged to consider the total power available from the ROBOT battery during the design and build of the ROBOT. Drawing large amounts of current from many motors at the same time could lead to drops in ROBOT battery voltage that may result in tripping the main breaker or brownout the Gorgon Flex.

R2. The integral mechanical and electrical system of any motor must not be modified. Motors, servos, and electric solenoids used on the ROBOT shall not be modified in any way, except as follows:

- **A.** The mounting brackets and/or output shaft/interface may be modified to facilitate the physical connection of the motor to the ROBOT and actuated part.
- **B.** The electrical leads may be trimmed to length as necessary and connectors or splices to additional wiring may be added.
- **C.** The locking pins on the window motors (P/N: 262100-3030 and 262100-3040) may be removed.
- **D.** Servos may be modified as specified by the manufacturer (e.g. re-programming or modification for continuous rotation).
- **E.** Minimal labeling applied to indicate device purpose, connectivity, functional performance, etc.

F. Any number of #10-32 plug screws may be removed from the Falcon 500. I. Insulation may be applied to electrical terminals.

The intent of this rule is to allow teams to modify mounting tabs and the like, not to gain a weight reduction by potentially compromising the structural integrity of any motor.

R3. With the exception of servos, fans, or motors integral to sensors of COTS computing devices permitted in R1, each actuator must be controlled by a power regulating device. The only power regulating devices for actuators permitted on the ROBOT include:

A. Motor Controllers
- i. Spark Motor Controller (P/N: REV-11-1200)
- ii. Spark MAX Motor Controller (P/N: REV-11-2158)
- iii. Talon FX Motor Controller (P/N: 217-6515, 19-708850, am-6515, am-6515_Short) for controlling integral Falcon 500 only
- iv. Talon Motor Controller (P/N: CTRE_Talon, CTRE_Talon_SR, and am-2195)
- v. Talon SRX Motor Controller (P/N: 217-8080, am-2854, 14-838288)
- vi. Victor SPX Motor Controller (P/N: 217-9191, 17-868388, am-3748)
- vii. Other 12 volt capable motor controllers with a purchase value of less than $75.00

B. Relay Modules
- **i.** Spike H-Bridge Relay (P/N: 217-0220 and SPIKE-RELAY-H)
- **ii.** Automation Direct Relay (P/N: AD-SSR6M12-DC-200D, AD-SSRM6M25-DC-200D, ADSSR6M45-DC-200D)

C. Pneumatics controllers
- **i.** Pneumatics Control Module (P/N: am-2858, 217-4243)

Note: The Automation Direct Relays are single directional. Per R4 they may not be wired together in an attempt to provide bi-directional control.

R4. Each power regulating device may control electrical loads per Table 5-1. Unless otherwise noted, each power regulating device shall control one and only one electrical load.

Table 5-1 Power regulating device allotments

Electrical Load	Motor Controller	Relay Module	Pneumatics Controller
AndyMark RedLine Motor Banebots CIM REV Robotics NEO Brushless REV Robotics NEO 550 VEX Mini-CIM WCP RS775 Pro	**Yes**	**No**	**No**
AndyMark 9015 VEXpro BAG	**Yes (up to 2 per controller)**	**No**	**No**

AndyMark PG KOP Automotive Motors NeverRest Snow Blower Motor	**Yes (up to 2 per controller)**	**No**	**No**
CTR Electronics/VEX Falcon 500 Nidec Dynamo BLDC Motor w/ Controller Playing With Fusion Venom	**Yes (integrated controller only)**	**No**	**No**
Compressor	**No**	**Yes**	**Yes**
Pneumatic Solenoid Valves	**No**	**Yes**	**Yes (1 per channel)**
Electric Solenoids	**Yes**	**Yes**	**Yes (1 per channel)**
CUSTOM CIRCUITS	**Yes**	**Yes**	**Yes (1 per channel)**

R5. Servos must be connected to, and only to, one of the following:
- **A.** PWM PORTS on the Gorgon Flex
- **B.** PWM PORTS on a WCP Spartan Sensor Board (P/N: WCP-0045)
- **C.** REV Robotics Servo Power Module (P/N: REV-11-1144)

5.5. Power Distribution

In order to maintain safety, the rules in this section apply at all times while at the event, not just while the ROBOT is on the FIELD for MATCHES.
Teams will be supplied batteries to use for use throughout the season.

R6. The only legal source of electrical energy for the ROBOT during the competition, the ROBOT battery, must be one and only one non-spillable sealed lead acid (SLA) battery with the following specifications:
- **A.** Nominal voltage: 12V
- **B.** Nominal capacity at 20-hour discharge rate: minimum 17Ah, maximum 18.2Ah
- **C.** Shape: Rectangular
- **D.** Terminals: Nut and bolt style

R7. COTS USB battery packs with a capacity of 100Wh or less (20000mAh at 5V) and 2.5 Amp max output per port, or batteries integral to and part of a COTS computing device or self-contained camera (e.g. laptop batteries, GoPro style camera, etc.) may be used to power COTS computing devices and any peripheral COTS input or output devices connected to the COTS computing device provided they are:
- **A.** securely fastened to the ROBOT,
- **B.** connected only using unmodified COTS cables, and
- **C.** charged according to manufacturer recommendations.

R8. Any battery charger used to charge a ROBOT battery must have the corresponding Anderson SB connector installed.

R9. Any battery charger used to charge a ROBOT battery may not be used such that it exceeds 6- Amp peak charge current.

R10. No batteries other than those allowed per R6 and R7 are allowed on the ROBOT, whether or not they are being used to supply power.

For example, teams may not use additional batteries as extra weight on their ROBOTS.

R11. The ROBOT battery must be secured such that it will not dislodge during vigorous ROBOT interaction including if the ROBOT is turned over or placed in any arbitrary orientation.

R12. Each electrical terminal on the ROBOT battery, main breaker, and their connections (lugs, stripped wire ends, etc.) to the wire must be fully insulated at all times.

R13. Non-electrical sources of energy used by the ROBOT, (i.e., stored at the start of a MATCH), shall come only from the following sources:

- **i.** compressed air stored in the pneumatic system that has been charged in compliance with R37 and R38,
- **ii.** a change in the altitude of the ROBOT center of gravity,
- **iii.** storage achieved by deformation of ROBOT parts,
- **iv.** closed-loop COTS pneumatic (gas) shocks, and
- **v.** air-filled (pneumatic) wheels.

R14. The one (1) ROBOT battery, a single pair of Anderson Power Products (or APP) 2-pole SB type connectors, the one (1) main 120-amp (120A) surface mount circuit breaker (Cooper Bussman P/N: CB185-120, CB185F-120, CB285-120), and the one (1) CTR Electronics Power Distribution Panel (PDP, P/N: am-2856, 217-4244, 14-806880) shall be connected with 6 AWG (7 SWG or 16 mm2) copper wire or larger, with no additional devices or modifications, as shown in Figure 5-1.

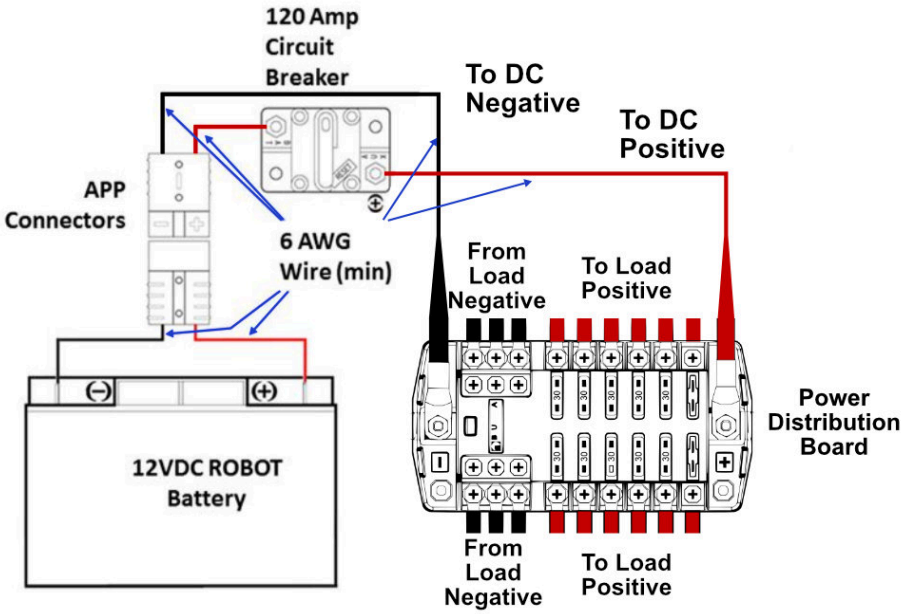

Figure 5-1. Electrical connection diagram

> "SB type" refers to SB type only (e.g. SB-50, SB-120, etc.), not SBS or any other part type beginning with SB. All batteries supplied by FIRST (such as Spare Parts and international batteries) will have a Red or Pink SB50 connector installed which may not be removed.
>
> The pink connectors included in the 2020 KOP mate with the Red SB50 connector.

R15. All wiring and electrical devices, including all Control System COMPONENTS, shall be electrically isolated from the ROBOT frame. The ROBOT frame must not be used to carry electrical current

> R15 is checked by observing a >3kΩ resistance between either the (+) or (-) post within the APP connector that is attached to the PDP and any point on the ROBOT.

All legal motor controllers with metal cases are electrically isolated. They may be mounted directly to ROBOT frame COMPONENTS.

Note that some cameras, decorative lights and sensors (e.g. some encoders, some IR sensors, etc.) have grounded enclosures or are manufactured with conductive plastics. These devices must be electrically isolated from the ROBOT frame to ensure compliance with R15.

R16. The 120A circuit breaker must be quickly and safely accessible from the exterior of the ROBOT. This is the only 120A circuit breaker allowed on the ROBOT.

Examples considered not "quickly and safely accessible" include breakers covered by an access panel or door, or mounted on, underneath or immediately adjacent to moving COMPONENTS.

It is strongly recommended that the 120A circuit breaker location be clearly and obviously labeled so it can be easily found by FIELD STAFF during a MATCH.

R17. The PDP, associated wiring, and all circuit breakers must be visible for Inspection

R18. Any active electrical item that is not an actuator (specified in R1) or core Control System item (specified in R66) is considered a CUSTOM CIRCUIT. CUSTOM CIRCUITS shall not produce voltages exceeding 24V.

R19. The Wireless Bridge (Radio) power must be supplied directly by the PDP though a 12V DC jack or by a POE injector.

R20. Only one wire shall be connected to each terminal on the PDP.

If multi-point distribution of circuit power is needed, then all incoming wires may be appropriately spliced into the main lead (e.g. using an insulated terminal block, crimped splice or soldered wire splice), and the single main lead with ring terminal attached to the binding post of the PDP to power the circuit.

R21. The only circuit breakers permitted for use in the PDP is the Snap Action VB3-A Series, terminal style F57.

R22. The fuses in the PDP shall only be replaced with functionally identical fuses (mini automotive blade fuses with values matching those printed on the PDP).

Note that these fuses must be pressed very firmly to seat properly. Improper seating can cause component reboots during impacts.

R23. Each branch circuit must be protected by one and only one circuit breaker on the PDP per Table 5-2. No other electrical load can be connected to the breaker supplying this circuit.

Table 5-2 Branch circuit protection requirements

Branch Circuit	Circuit Breaker Value	Quantity Allowed Per Breaker
Motor Controller	Up to 30A	1
CUSTOM CIRCUIT	Up to 30A	1
Automation Direct Relay 40A (*6M40*)	Up to 30A	1

Fans permitted per Table 9-1 and not already part of COTS computing devices	Up to 20A	No limit
Spike Relay Module	Up to 20A	1
Automation Direct Relay 25A (*6M25*)	Up to 20A	1
Compressor via relay	20A	1
Additional VRM (non-radio)	20A	3 total
Automation Direct Relay 12A (*6M12*)	Up to 10A	1

does not prohibit the use of smaller value breakers in the PDP or any fuses or breakers within CUSTOM CIRCUITS for additional protection.

R24. All circuits shall be wired with appropriately sized insulated copper wire (SIGNAL LEVEL cables don't have to be copper):

Table 5-3 Breaker and wire sizing

Application	Minimum Wire Size
21 - 30A protected circuit	14 AWG (16 SWG or 2.5 mm2)
6 - 20A protected circuit Between the PDP and the VRM or compressor relay.	18 AWG (19 SWG or 1 mm2)
Between the PDP and the Gorgon Flex	22 AWG (22 SWG or 0.5 mm2)
VRM 2A circuits	24 AWG (24 SWG or .25mm2)
Gorgon Flex PWM port outputs	26 AWG (27 SWG or 0.14 mm2)
SIGNAL LEVEL circuits (i.e. continuous and have a source incapable of delivering >1A, including but not limited to Gorgon Flex non-PWM outputs, VRM 500mA outputs and Arduino outputs)	28 AWG (29 SWG or .08 mm2)

Wires that are recommended by the device manufacturer or originally attached to legal devices are considered part of the device and by default legal. Such wires are exempt from R24.

In order to show compliance with these rules, teams should use wire with clearly labeled sizes if possible. If unlabeled wiring is used, teams should be prepared to demonstrate that the wire used meets the requirements of R24 (e.g. wire samples and evidence that they are the required size).

R25. Branch circuits may include intermediate elements such as COTS connectors, splices, COTS flexible/rolling/sliding contacts, and COTS slip rings, as long as the entire electrical pathway is via appropriately gauged/rated elements.

Slip rings containing mercury are prohibited.

R26. All non-SIGNAL LEVEL wiring with a constant polarity (i.e., except for outputs of relay modules, motor controllers, or sensors) shall be color-coded along their entire length from the manufacturer as follows:

- **A.** Red, yellow, white, brown, or black-with-stripe on the positive (e.g. +24VDC, +12VDC, +5VDC, etc.) connections.
- **B.** Black or blue for the common or negative side (-) of the connections.

Exceptions to this rule include:

- **C.** Wires that are originally attached to legal devices and any extensions to these wires using the same color as the manufacturer.
- **D.** Ethernet cable used in POE cables.

R27. CUSTOM CIRCUITS shall not directly alter the power pathways between the ROBOT battery, PDP, motor controllers, relays (per R3.B), motors and actuators (per **Error! Reference source not found.**), pneumatic solenoid valves, or other elements of the ROBOT control system (items explicitly mentioned in R66). Custom high impedance voltage monitoring or low impedance current monitoring circuitry connected to the ROBOT'S electrical system is acceptable, if the effect on the ROBOT outputs is inconsequential.

A noise filter may be wired across motor leads or PWM leads. Such filters will not be considered CUSTOM CIRCUITS and will not be considered a violation of R56 or R73. Acceptable signal filters must be fully insulated and must be one of the following:

• A one microfarad (1 µF) or less, non-polarized, capacitor may be applied across the power leads of any motor on your ROBOT (as close to the actual motor leads as reasonably possible).

• A resistor may be used as a shunt load for the PWM control signal feeding a servo.

5.6. Control, Command & Signals System

R2. ROBOTS must be controlled via one (1) programmable Gorgon Flex and Ethernet Robot Controller (P/N: am2900)

There are no rules that prohibit co-processors, provided commands originate from the Gorgon Flex to enable and disable all power regulating devices.

R28. One (1) OpenMesh Wireless Bridge (P/N: OM5P-AN or OM5P-AC) is the only permitted device for communicating to and from the ROBOT during the MATCH.

R29. The Gorgon Flex Ethernet PORT must be connected to the Wireless Bridge PORT labeled "18-24 vPOE," closest to the power connector (either directly, via a network switch, or via a CAT5 Ethernet pigtail).

R30. The Wireless Bridge must be mounted on the ROBOT such that the diagnostic lights are visible.

Teams are encouraged to mount the wireless bridge away from noise generating devices such as motors.

R31. Every relay module (per R3.B), servo controller, and PWM motor controller shall be connected to a corresponding port (relays to Relay ports, servo controllers and PWM controllers to PWM ports) on the Gorgon Flex. They shall not be controlled by signals from any other source, with the exception of the Nidec Dynamo motor controller which must also be connected to the Gorgon Flex Digital I/O.

5.7. Pneumatic System

In order to maintain safety, the rules in this section apply at all times while at the event, not just while the ROBOT is on the FIELD for MATCHES.

R32. To satisfy multiple constraints associated with safety, consistency, Inspection, and constructive innovation, no pneumatic parts other than those explicitly permitted in this section shall be used on the ROBOT

R33. All pneumatic items must be COTS pneumatic devices and either:

- **A.** rated by their manufacturers for pressure of at least 125psi (~862 kPa), or
- **B.** installed downstream of the primary relieving regulator (see R82), and rated for pressure of at least 70psi (~483 kPa).

> Any pressure specification such as “working,” “operating,” “maximum,” etc. may be used to satisfy the requirements of R33.
>
> It is recommended that all pneumatic items be rated by their manufacturers for a working pressure of at least 60 psi (~414 kPa).

R34. All pneumatic COMPONENTS must be used in their original, unaltered condition. Exceptions are as follows:

- **A.** tubing may be cut,
- **B.** wiring for pneumatic devices may be modified to interface with the control system,
- **C.** assembling and connecting pneumatic COMPONENTS using the pre-existing threads, mounting brackets, quick-connect fittings, etc.,
- **D.** removing the mounting pin from a pneumatic cylinder, provided the cylinder itself is not modified,
- **E.** labeling applied to indicate device purpose, connectivity, functional performance, etc.

> Do not, for example, paint, file, machine, or abrasively remove any part of a pneumatic COMPONENT – this would cause the part to become a prohibited item. Consider pneumatic COMPONENTS sacred.

R35. The only pneumatic system items permitted on ROBOTS include the items listed below.

- **A.** Pneumatic pressure vent plug valves functionally equivalent to those provided in the KOP,

> Examples of acceptable valves include Parker PV609-2 or MV709-2.

- **B.** Pressure relief valves functionally equivalent to those provided in the KOP,

> Examples of acceptable valves include Norgren 16-004-011, 16-004-003 or McMaster-Carr 48435K714.
>
> To be considered functionally equivalent the valve must be preset or adjustable to 125 psi (~862 kPA) and capable of relieving at least 1 scfm (~472 cm3/s).

- **C.** Solenoid valves with a maximum ⅛ in. (nominal, ~3 mm) NPT, BSPP, or BSPT port diameter or integrated quick connect ¼ in. (nominal, ~6mm) outside diameter tubing connection,
- **D.** Additional pneumatic tubing, with a maximum ¼ in. (nominal, ~6 mm) outside diameter,
- **E.** Pressure transducers, pressure gauges, passive flow control valves (specifically “needle valve”), manifolds, and connecting fittings (including COTS pneumatic U-tubes),
- **F.** Check and quick exhaust valves, provided that the requirements of R86-A are still met,

G. Shutoff valves which relieve downstream pressure to atmosphere when closed (may also be known as 3-way or 3-way exhausting valves),
H. Pressure regulators with the maximum outlet pressure adjusted to no more than 60 psi (~413 kPa),
I. Pneumatic cylinders, pneumatic linear actuators, and rotary actuators,
J. Pneumatic storage tanks (with the exception of White Clippard tanks P/N: AVT-PP-41),
K. One (1) compressor that is compliant with R79,
L. Debris or coalescing (water) filters, and
M. Venturi valves (note: the high-pressure side of a Venturi valve is considered a pneumatic device and must follow all pneumatic rules. The vacuum side of a Venturi valve is exempt from the pneumatic rules per "a" in the Blue Box below).

The following devices are not considered pneumatic devices and are not subject to pneumatic rules (though they must satisfy all other rules):
a. a device that creates a vacuum
b. closed-loop COTS pneumatic (gas) shocks
c. air-filled (pneumatic) wheels
d. pneumatic devices not used as part of a pneumatic system (i.e. used in a way that does not allow them to contain pressurized air)

R36. If pneumatic COMPONENTS are used, the following items are required as part of the pneumatic circuit and must be used in accordance with this section, as illustrated in Figure 5-2.

A. One (1) FIRST Robotics Competition legal compressor (per R37)
B. Pressure relief valve (per R35.B) connected via legal rigid fittings (e.g. brass, nylon, etc.)
C. Nason pressure switch, P/N SM-2B-115R/443
D. At least one pressure vent plug
E. Stored pressure gauge (upstream from Primary Regulator, must show psi or kPa)
F. Working pressure gauge (downstream from Primary Regulator, must show psi or kPa)
G. Working pressure regulator

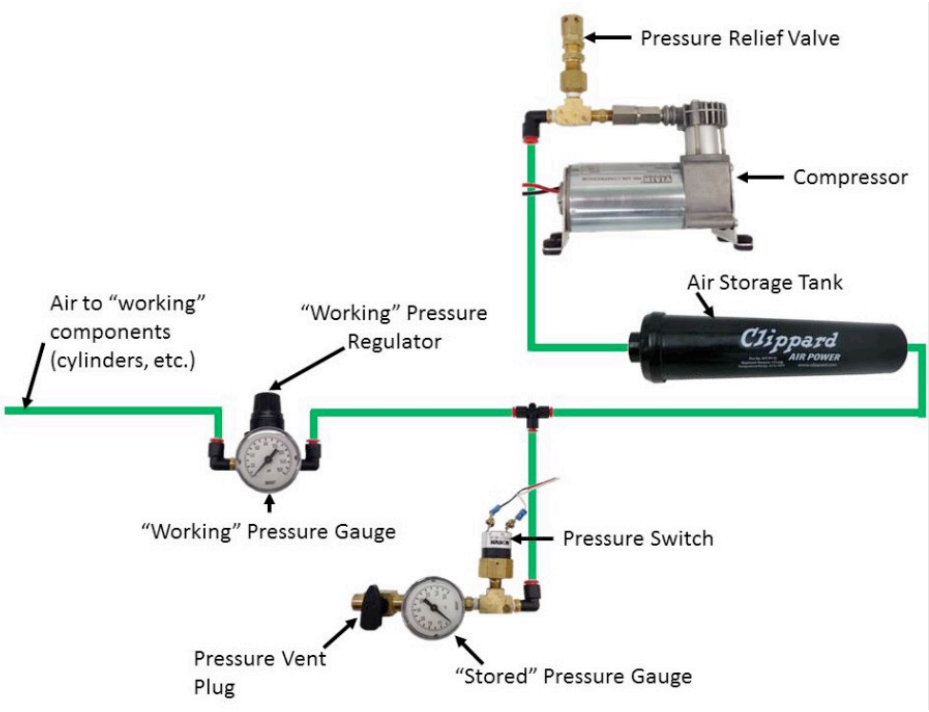

Figure 5-2. Pneumatic circuitry

R37. Throughout an event, compressed air on the ROBOT must be provided by its one onboard compressor only. Compressor specifications must not exceed nominal 1.1 cfm (~519 cm3/s) flow rate @ 12VDC at any pressure.

> A ROBOT'S compressor may be substituted by another compressor, but a ROBOT may only have one designated compressor at a time, and all compressed air on the ROBOT must be sourced from a single compressor.
>
> Note: Viair C-series compressors, which have a max working pressure of 120 PSI, are rated for intermittent pressures greater than 125 PSI and therefore meet the requirements of R33.

R38. Stored air pressure on the ROBOT must be no greater than 120 psi (~827 kPa). No stored air pressure intended for the ROBOT may be located off-board the ROBOT.

R39. Working air pressure (air pressure used to actuate devices) on the ROBOT must be no greater than 60 psi (~413 kPa) and must be provided through a single primary adjustable, relieving, pressure regulator.

> Examples of acceptable valves include: Norgren regulator P/N: R07-100-RNEA or Monnier P/N: 101-3002-1.

R40. Only the compressor, relief valve, pressure switch, pressure vent plug, pressure gauge, storage tanks, tubing, pressure transducers, filters, and connecting fittings may be in the high-pressure pneumatic circuit upstream from the regulator.

> It is recommended that all COMPONENTS in the high-pressure pneumatic circuit upstream from the regulator be rated for at least 115 psi (~793 kPa) working pressure.

R41. Pressure gauges must be placed in easily visible locations upstream and downstream of the regulator to display the stored and working pressures.

R42. The relief valve must be attached directly to the compressor or attached by legal hard fittings (e.g. brass, nylon, etc.) connected to the compressor output port. Teams are required to check and/or adjust the relief valve to release air at 125 psi (~861 kPa). The valve may or may not have been calibrated prior to being supplied to teams.

> Instructions for adjusting the pressure relief valve can be found in the Pneumatic Manual.

R43. The pressure switch requirements are:

- **A.** It must be Nason P/N: SM-2B-115R/443.
- **B.** It must be connected to the high-pressure side of the pneumatic circuit (i.e. prior to the pressure regulator) to sense the stored pressure of the circuit.
- **C.** The two wires from the pressure switch must be connected directly to a Digital I/O input pin on the Gorgon Flex
- **D.** The Gorgon Flex must be programmed to sense the state of the switch and operate the relay module that powers the compressor to prevent overpressuring the system.

R44. Any pressure vent plug must be:

- **A.** connected to the pneumatic circuit such that, when manually operated, it will vent to the atmosphere to relieve all stored pressure in a reasonable amount of time, and
- **B.** placed on the ROBOT so that it is visible and easily accessible.

R45. The outputs from multiple solenoid valves must not be plumbed together.

6. Manual Updates

Version 1.0 – 2/6/2021 – Initial Release
Version 1.1 – 2/16/2021 – Update 1