UVM AIKEN ENGINEERING CHALLENGE

The Aiken Engineering Challenge is a program supported by the University of Vermont George D. Aiken Lectures that aims to involve young Vermonters in engineering and technology, a topic that long interested Senator Aiken.

Students will build a device to meet an engineering challenge, and compete with their device at an event held at UVM. This year the event will be on Saturday, November 19, at the Davis Center. The Aiken Challenge will be held in conjunction with a "Maker" event which will include a number of activities and exhibits.

This challenge is an achievable one and can be solved using ordinary hand tools, readily available materials, robotic components that most schools already have, and for a reasonable cost, but there is real engineering involved. The students will need to analyze the problem, consider a variety of solutions, build a trial solution, test it, make improvements, and build a final design that is robust and reliable. The challenge is structured so that almost any team can achieve some success, but it is not easy to win.

Students experience hands-on learning and engineering thought, both necessary to solve any number of contemporary real world challenges in energy, agriculture, the environment, and communication.

1.0 THE CHALLENGE FOR NOVEMBER, 2016 - SUMMARY

Robots play on a 6' x 8' flat surface with a curb around the edge. Red and blue wooden blocks are positioned near the center of the field. The object of the game is to bring the blocks into the Robot's Goal and stack them. The more blocks in the Goal, and the higher the stacks, the higher the score.

Four robots play at the same time, in teams of two, a Red Alliance against a Blue Alliance. Each team will play four Matches and will be randomly paired with a different Alliance partner for each Match.

Robots may collect and move blocks, stack blocks, and interfere with the opponent's robots and blocks. Robots may also attempt to remove blocks in the opponent's Goal and also knock over an opponent's stacks. Teams on an Alliance will need to work together to achieve success.

There is an area near the center of the field where the opposing Alliances can cooperate to build additional stacks for bonus points.

Points earned for all four Matches will be totaled; if time permits, there will be a playoff round for the top four teams.
2.0 THE PLAYING FIELD

![Image of the Playing Field](image)

**Figure 1 The Playing Field - 6' x 8'**

- The Playing Field (Figure 1) is made from two pieces of Masonite, smooth side up, with a 1 x 4 upturned curb on all sides. A double 1 x 4 barrier is at the center line, with gaps for the Game Pieces and the Cooperation Zone.
- Starting Areas for each Alliance, 12" x 12", dark red and dark blue, are painted on the surface at each end of the field. The Goals for each Alliance are painted a lighter shade of red and blue.
- A "Safety Line" at each end of the field is drawn on the surface 18" from the end of the field.
- A Cooperation Zone, 8" x 8" is painted at the center of the field.
- The Playing Field will be placed directly on the carpet at the event venue, Davis Center.
- A Staging Area approximately 5' x 10' will be available near the Playing Field where tools and other supplies necessary for the match may be placed.

In addition to Figure 1 above, Section 9.1, Figure 3 shows additional details of the construction of the Playing Field.
3.0 GAME PIECES

The Game Pieces consist of:

- 1" x 1" x 1" wood blocks painted red and blue, available from Woodworks Ltd. <orders@craftparts.com>

The Game Pieces for the event will be provided by the Aiken Challenge Committee.

Game Pieces may not be marked, altered, or added to in any way.

4.0 THE ROBOT

Each team shall make a "Robot" to move Game Pieces.

- A "Robot" means a device which moves and operates, using a power source contained in the robot, after being positioned on the Playing Field and energized.
- A Robot may use wheels, rollers, tracks, skids, legs, or other devices to move about.
- A Robot may use arms, claws, pushers, bumpers, conveyors, shooters, or other safe devices to move Game Pieces.
• Teams may use or adapt commercially available products, such as RC cars, Lego vehicles and parts, Tetrix parts, etc.

• The starting configuration of the Robot shall be no more than 12" wide by 12" long by 24" high. During game play there are no limitations to the dimensions of the Robot except that the supporting elements at point of contact with the Playing Field may never project beyond a 12” x 12” square.

  In other words, the “wheelbase” of a Robot can never exceed 12” x 12”.

• All parts of the robot must remain physically connected to the core at all times. A Robot may not intentionally detach and leave elements or devices on the Playing Field, even momentarily. Any type of projectile used must be on a tether and must be retrieved by the robot itself immediately after use to avoid entangling other robots; the robot must remain outside the Safety Line.

• The Robot shall weigh no more than 15 lbs. including on-board batteries.

• Any energy source(s) which are safe may be used for the Robot. Allowable energy sources include: springs, rubber cords, gravity, batteries, capacitors, kinetic energy, wind-up devices. This is not intended to be a complete list; other safe energy sources are allowed.

• Prohibited energy sources include: open chemical reactions, flame, explosive energy, compressed air, or any other unsafe source. No water or other liquids are allowed. Batteries which can spill if tipped over are not allowed. Springs and similar stored energy devices must not pose any undue risks to participants or observers. Energy sources may not damage the Playing Field or create clean-up problems.

• A Robot may be controlled by any safe means including electromagnetic or radio control. A Robot may also operate autonomously.

• Robots may not use a tether between the robot and its control system as it may pose entanglement issues with other Robots. Control of the robot must be by wireless.

• Robots must display a red or blue indicator which can be changed to indicate its Alliance assignment for the Match. The nature of the indicator is not specified; it must be clear and easily read. It must be clearly visible from all sides of the Robot.

5.0 GAME PLAY

5.1 Alliances

Four Robots will play in each Match,

• An Alliance of two red Robots,
• An Alliance of two blue Robots.
Alliances will be randomly assigned by the Judges as teams appear and register on event day. Match assignments and approximate Match times will be posted. Insofar as possible two teams from the same school will not be assigned to the same Alliance. Any team that registers at the event after 9:00 am will only be allowed to play three Matches.

Teams are required to be aware of the progress of the tournament and must be ready to appear at the required time for all Matches. If for any reason a team is required to play a Match without an Alliance partner it’s score will be doubled. A team that fails to appear for a Match will receive a zero score for that Match.

It will pay to keep track of Match progress and be on time.

5.2 Starting Positions

There will be 24 Game Pieces (blocks) of each color. The Game Pieces will be positioned for the start by the Judges near the center of the field as shown in Figure 1.

Two Robots of each color will be positioned by the teams in their two Starting Areas as shown in Figure 1. The Robots must be entirely within the Starting Area.

A maximum of three minutes are allowed for set-up. When the field and Robots are ready the Judges will start the Match; play continues for 5 minutes.

5.3 Moving Game Pieces

The Robots may move and position Game Pieces by pushing, lifting, shooting, carrying, or any other safe means.

Game Pieces which are entirely located in their respective red and blue Goals at the end of the Match are scored as described in Paragraph 6.0. Game Pieces which are stacked in the Goals receive additional points. Game Pieces located in the red and blue Starting Areas are not scored.

The opposing Alliances may cooperate to construct stacks on the Cooperation Zone. To be scored such stacks must be composed of alternating red and blue blocks. A team may only stack blocks of its own color.

Robots may touch and move an opponent's Game Pieces, but a penalty applies in certain circumstances; refer to Section 6.4.

5.4 Attacking an Opponent’s Game Pieces and Stacks

A robot may remove Game Pieces from an opponent's Goal, and may knock over an opponent's stacks. However these actions must be undertaken with all the supporting elements of the attacking Robot outside the Safety Line. If any supporting element of a Robot crosses the Safety Line at any time a penalty will be imposed; refer to Section 6.4.
In other words, in order to attack an opponent's scored Game Pieces or stacks a Robot must stay behind the Safety Line and use a device of some kind which extends or deploys from the Robot.

5.5 **Contacting an Opposing Robot**

Contact between robots is expected, but **must not** be with the intention of causing damage. Robots **may** attempt to overturn another robot, but without the intention of causing damage. A penalty will be imposed in case of intention to cause damage. Refer to Section 6.4.

5.6 **Assisting a Failed Robot**

If a Robot tips over, either by accident or by action of an opponent, it **may** be righted in the same location.

A Robot which has failed or needs adjustment during a Match **may** be removed from the course, repaired, and returned to the location where it failed.

Before assisting a failed robot the team must inform the Judges and receive permission to enter the Playing Field. Permission will be granted when it is safe to do so. Play will stop and the clock will stop while you are on the Field.

Play will stop and the clock will stop while you are on the field to right or remove your robot, but not while you are repairing your robot outside of the Field.

5.7 **Location of Team Members During the Match**

**One or two** team members, the Driver(s), may move about the outside of the Playing Field during the Match.

**One** team member may retrieve and return a failed robot, or right an overturned robot.

Otherwise all team members must remain in the designated Staging Area or in spectators areas.

6.0 **Scoring**

For each Match the score for **each robot on each Alliance** will be the sum of the Basic Score, the Cooperation Score, and for the winners of the Match, the Winner's score.

6.1 **Basic Score**

The GOAL: Get as many of your colored blocks into your Goal. Points are scored by the number in the Goal.
If blocks are stacked in the Goal each layer counts as follows (Fibonacci) sequence.

<table>
<thead>
<tr>
<th>Height of stack</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
</table>

Points will be calculated at the end of the Match based on the location of Game Pieces and the existence of stacks at that time. Both teams on the Alliance receive the score earned by the Alliance.

Game Pieces which may have been stacked at some point but have been knocked over will not be scored as stacks.

Game Pieces and stacks will not be scored if they are touching any part of a Robot at the end of the Match, but may be touching the curb at the edges of the Field. Game Pieces located in the red and blue Starting Areas are not scored.

6.2 Cooperation Score

The GOAL: Cooperate with the opposing robots to build stacks of blocks on the Cooperation Zone. Blocks must be alternating in color. Cooperation points are awarded to all teams on both Alliances as follows:

<table>
<thead>
<tr>
<th>Height of stack</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
</table>

6.3 Winner’s Score

Both robots on the winning Alliance will be awarded a bonus of 50 points. In the event of a tie the bonus will be split between the Alliances.

6.4 Penalties

- If any supporting element of an attacking Robot crosses the opponent's Safety Line at any time the Judges will stop play, stop the clock, pick up the attacking Robot and return it to its own Starting Position. If the attacking robot has knocked over an opponent's stack while across the Safety Line the Judges
deconstruct the tallest of the attacking Robot's stacks, or, if there are no such stacks, will remove five of the attacking Robot's Game Pieces from Play.

To avoid this penalty Robots must stay behind the Safety Line and use a device of some kind which extends or deploys from the Robot to attack the opponent's Game Pieces or stacks. Note that any projectile used to attack an opponent's stacks must be on a tether, and must be retrieved immediately by the robot itself after use; the robot must remain outside the Safety Line.

- If at any time and for any reason Game Pieces become located inside the opponent's Safety Line, the Judges will stop play, stop the clock, remove them, and place them in Starting Position. If a robot is in possession of an opponent's Game Pieces while inside its own Safety Line, the Judges will likewise stop play, stop the clock, remove them, and place them in Starting Position.

Robots may move the opponent's Game Pieces about the field as desired, but not inside their own Safety Line.

- A Robot may not eject an opponent’s Game Pieces from the Playing Field. The Judges will retrieve any Game Pieces so ejected and place them in the opponent’s Goal. (If a robot ejects its own Game Pieces they will remain off the field, out of play.)

- Although contact between robots is expected it is not in the spirit of the tournament to intentionally damage another robot. Robots that pose an undue danger to other robots will not be allowed to compete. If the Judges observe robot actions during the Match which seem intended to cause damage they will remove the offending Robot from play for at least one minute.

### 7.0 THE TOURNAMENT

There will be more than one Playing Field if necessary to allow all contestants to complete the Qualification Round within a period of approximately 3-4 hours.

### 7.1 Engineering Design Presentation (optional)

Each team has the option to make a 10 minute verbal and poster presentation describing their Robot and control system. Teams wishing to make a presentation must opt-in by sending an e-mail to mailto: jimwick.vt@gmail.com on or before October 21, 2016 informing the committee of its wish to present.

Note that two awards, the Engineering Design Presentation Award, and the Modeling, Testing, and Documentation Award will be based on this presentation.

On event day there will be a Presentation Manager and a sign-up sheet where each team may schedule its presentation between Matches.
Your presentation should include:
Each team should provide a poster that describes how their system operates. Each poster should include:

- A description of how your Robot operates (including a diagram)
- Highlight any advantages of your design and why it might be better than the competition.
- Examples of numerical modeling you may have used to design your Robot and/or determine the best strategy.
- Pictures and/or records of tests you performed with the Robot.

Your presentation should cover:

- Key features of the systems and of the construction of your Robot and control system and how its design may have been derived from your modeling and testing.
- Your strategy for the competition and how it may have been derived from your modeling and testing.
- How you optimized your system to meet the Goals of your strategy.
- Particular challenges which you encountered and your response to those challenges.

The rubric that will be used to score the presentations is listed in Section 9.5.

7.2 The Qualification Matches

Each Team will play four Qualification Matches:

- 3 minutes for whatever the team wishes to do for set-up, calibration, and tests. This is the Set-up Period. Teams do not need to use the full 3 minutes for set-up. However, any remaining time will not be added to the Match.
- 5 minutes for the Match during which Game Pieces are moved and scored. This time must start no later than 3 minutes from the start of the Set-up Period. Teams shall indicate to the Judges when they wish begin to their Match.

The team must remove their devices from the Staging Area and Playing Field promptly after the end of the Match. Teams that fail to do so will receive a 25 point penalty.

7.3 Extra Matches

It is likely that the number of teams present on event day will not be divisible by four, and hence it will be possible and desirable for teams to play one extra Match so that all Matches have four teams.

There will be a sign-up sheet for teams who wish to play an extra match.

Only four matches will be included in the total for any team. Before playing an extra match a team must indicate which of their previous scores they wish to exclude.
7.4 **Playoff Round**

If time permits there will be a playoff round.

The **four** teams with the highest calculated scores in the Qualification Matches will play with two Matches. The teams ranked 1 and 4 will play against 2 and 3. In the Championship Round teams from the same school **may** be on the same Alliance.

7.5 **Prizes**

The prize categories and number of prizes will be defined based on the number of registered teams as of October 21, 2016. There will be **at least** the following prize categories:

- Engineering Design Presentation Award
- Best Calculated score for the Qualification Matches. (HS and MS prizes)
- Modeling, Testing, and Documentation Award

A team **may** win more than one prize.

8.0 **Miscellaneous Provisions**

- Teams may consist of at least **two** but not more than **six** members. Team members must be in grades 7-12; there are no age restrictions. "Middle School" means what the school district considers middle school; all members of a middle school team must be in middle school. Team members from more than one school or organization may participate on the same team. An adult is required to be the team advisor; the advisor does not need to be a teacher. Groups such as Boy Scouts, Girl Scouts, 4H groups, and ad-hoc groups are encouraged to participate.

- The total number of teams participating will be limited to the **first 40 teams** that register on or before October 21, 2016. The registration form is on the website at [www.uvm.edu/~cems/TASC/](http://www.uvm.edu/~cems/TASC/).

- A scoresheet will be filled out by the Judges for each match. The **Judges** are responsible for bringing scoresheets to the Scoring Judge.

- Your system cannot pose a danger to your team, others in the venue, or to the floor and walls. If the Judges believe your system is dangerous, you will not be allowed to run until and unless the problem is corrected. Behavior intended to damage another robot will be penalized; refer to Section 6.4. Team may ask for a confidential ruling on their design prior to the event if they wish.

- Questions about the rules or anything else regarding **AIKEN CHALLENGE** may be submitted to: [mailto:jimwick.vt@gmail.com](mailto:jimwick.vt@gmail.com). We will try to post questions and answers promptly, but sometimes a questions will require the review of the full committee and may take a few days.
• If you have specific questions but you do not wish to reveal details of your design, you can request a confidential reply. Since answers to new questions will normally be posted as part of the Q&A, please identify any confidential question as “confidential reply requested” so that we do not accidentally post it.

8.1 October Report Bonus

It is helpful to the Aiken Challenge Committee to know about the emerging designs prior to the event. Therefore any team which submits a brief description of their Robot together with snapshots on or before October 21, 2016 will receive 25 bonus points. To receive bonus points your submission must be reasonably clear and understandable. It must include information on the construction of your robot, your probable control system, and at least one example of a spreadsheet you have made to analyze the challenge. All submissions will be held in strict confidence. Submissions should be made to: mailto:jimwick.vt@gmail.com.

You may continue to change and develop your design after you have made this submission.
9.0 Appendices

9.1 The Playing Field and Its Surface Features

Figure 3 The Playing Field and Surface Features
9.2 **Practice Fields**

Teams are encouraged to build a practice field. You should **not** bring your field to the competition on account of space constraints.

9.3 **Glossary**

**Match:** a 5 minute period during which points may be earned.

**Playing Field:** the flat surface shown in Figure 1. Refer also to Section 9.1, Figure 3.

**Possession:** (of a Game Piece): a Robot is in possession of a Game Piece if it is able to control its movement.

**Robot:** a device which moves and operates under its own power after being positioned on the Playing Field and energized.

**Stack:** one or more Game Pieces resting on top of one another. To be scored a stack may not be in contact with any robot at the end of the game, but **may** be in contact with the curb of the Playing Field.

Each Game Piece in a stack must be supported by only **one** piece below it.

In other words, a pyramid of blocks will **not** count as a stack.

**Staging Area:** an area approximately 5 feet x 10 feet near the Playing Field.

**Set-up Period:** a period of time, not to exceed 3 minutes, prior to a Match.
9.4 Scoresheet

<table>
<thead>
<tr>
<th>Aiken Engineering Challenge - Scoresheet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Match Number ____________</td>
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</table>

<table>
<thead>
<tr>
<th>Participating Teams</th>
<th>Red Alliance</th>
<th>___________________</th>
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<tbody>
<tr>
<td></td>
<td>___________________</td>
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<td></td>
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<table>
<thead>
<tr>
<th>Blue Alliance</th>
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<tbody>
<tr>
<td>___________________</td>
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<td>___________________</td>
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<table>
<thead>
<tr>
<th>Red Alliance Score</th>
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</thead>
<tbody>
<tr>
<td>Stacks:</td>
</tr>
<tr>
<td>Height of Stack</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>How Many Stacks</td>
</tr>
<tr>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Blue Alliance Score</th>
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</thead>
<tbody>
<tr>
<td>Stacks:</td>
</tr>
<tr>
<td>Height of Stack</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>How Many Stacks</td>
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<table>
<thead>
<tr>
<th>Cooperation Score</th>
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<tbody>
<tr>
<td>Stacks:</td>
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<tr>
<td>Height of Stack</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>How Many Stacks</td>
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<tr>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Game Pieces on Field but Unscored</th>
<th>________________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Game Pieces Removed from Field</td>
<td>________________</td>
</tr>
</tbody>
</table>
9.5 **Engineering Design Presentation Scoring Rubric**

Note that **two** awards, the Engineering Design Presentation Award, and the Modeling, Testing, and Documentation Award will be based on this presentation.

<table>
<thead>
<tr>
<th>Scoring Category</th>
<th>Description of criteria for scoring</th>
<th>Score</th>
<th>0</th>
<th>4</th>
<th>8</th>
<th>12</th>
<th>16</th>
<th>20</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presentation Content &amp; Structure</td>
<td>Does the presentation contain all required elements and how well organized/effective is its structure. (Refer to Section 7.1 for requirements.)</td>
<td></td>
<td>The presentation has no real structure or content.</td>
<td></td>
<td>The presentation contains most elements of the necessary content, but may not be effectively organized to effectively communicate it.</td>
<td></td>
<td>The presentation contains all of the necessary content in minimal form and is reasonably well organized.</td>
<td></td>
</tr>
<tr>
<td>Presentation Quality</td>
<td>How well is the presentation given. Criteria include: clarity of voice, eye contact, effectiveness of expression, body language, charisma, flow, effectiveness of poster as a visual aide, etc.</td>
<td></td>
<td>The delivery of the presentation clearly lacks rehearsal and the way in which it is presented significantly detracts from the content.</td>
<td></td>
<td>The delivery of the presentation does not significantly detract from the content, but is not effective.</td>
<td></td>
<td>The delivery of the presentation is effective, but stiff, lacks charisma, and/or does not flow well.</td>
<td></td>
</tr>
<tr>
<td>Solves Problem</td>
<td>Measure of how well the team's Robot and control system solves/addresses the basic elements of the problem: 1) Ability to position the Game Pieces. 2) Ability to stack Game Pieces 3) Ability to attack opponent's Game Pieces or stacks. 4) Ability to defend against attacks.</td>
<td></td>
<td>The Robot and control system does not solve any of the basic elements of the problem.</td>
<td></td>
<td>The Robot and control system adequately solves 1 basic element of the problem.</td>
<td></td>
<td>The Robot and control system adequately solves 2 basic elements of the problem.</td>
<td></td>
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</tbody>
</table>
### Engineering Tests

Measure of the quality of engineering modeling/testing prior to the competition:

1) Modeling/testing data were provided.
2) Modeling/testing addresses how to maximize scoring.
3) Modeling/testing were used to develop competition strategy (type of Robot, target areas, team work).
4) Modeling/testing were used to modify and/or validate design.
5) Modeling/testing demonstrate understanding of physics and mechanics.

<table>
<thead>
<tr>
<th></th>
<th>No modeling/test data provided.</th>
<th>Modeling/test data marginally addresses 1-5.</th>
<th>Modeling/test data address most aspects of 1-5.</th>
<th>Modeling/test data address all aspects of 1-5. and is exceptional or distinctive in some aspects of 1-5.</th>
<th>Modeling/test data addresses all aspects of 1-5 and is exceptional or distinctive in all aspects of 1-5.</th>
</tr>
</thead>
</table>

### Team Participation

How well the team works together as a group to contribute to the presentation.

<table>
<thead>
<tr>
<th></th>
<th>No participation by the team.</th>
<th>Presentation dominated by select individuals.</th>
<th>Most team members participate in presentation.</th>
<th>Most members contribute significantly to the presentation.</th>
<th>All members contribute to the presentation.</th>
<th>All members contribute significantly (~equal contributions across entire team).</th>
</tr>
</thead>
</table>