

# State of Iowa Physics Competition

## OFFICIAL 2019-2020 RULES

### Rules/Advisory Committee

Larry Escalada, University of Northern Iowa  
Chris Like, Bettendorf CSD  
Jeff Morgan, University of Northern Iowa  
Meghan Lang, Cedar Falls High School

Jason Martin-Hiner, Keystone AEA  
Tami Plein, Great Prairie AEA (Retired)  
Amanda Sanderman, Central Rivers AEA  
Marcy Seavey, University of Northern Iowa

### Table of Contents

<b><u>Overview</u></b>	<b>1</b>
Contact Information	2
State Competition Definitions and Clarifications	2
Device Rules	2
Scoring - Final Round	3
Rulings and Appeal	3
Awards	3
Schedule, Costs, and Information	4
<b><u>Events</u></b>	<b>5</b>
<u>CATAPULT</u>	5
<u>MOUSETRAP CAR</u>	6
<u>BRIDGE BUILDING</u>	8
<u>SODA STRAW ARM</u>	10
<u>MEASUREMENT</u>	13
<b><u>Judge and Event Director Checklists</u></b>	<b>17</b>
<u>CATAPULT Checklist</u>	17
<u>MOUSETRAP CAR Checklist</u>	18
<u>BRIDGE BUILDING Checklist</u>	19
<u>SODA STRAW ARM Checklist</u>	20
<u>MEASUREMENT Checklist</u>	21

### Overview

The State of Iowa Physics Competition has been revised for 2019-2020 to include one open state competition that includes preliminary and final rounds on the same day with the preliminary round in the morning and the final round in the afternoon. The preliminary round replaces the regional competition to be used as a qualifier for the final round for the state competition. Regional competitions may still be held for teams to practice for the state competition but teams still must qualify in the preliminary round on the day of the state competition to move onto the final round. Each participating school will be allowed to bring up to 3 entries per event (or 3 event teams) for the State of Iowa Physics Competition preliminary round and those who will qualify will move onto the final round. A school's highest scoring event team per event will be used to determine a

school's overall competition score.

The State of Iowa Physics Competition is a series of 5 physics events for high school (Grades 9-12) students. The competition stresses creativity and ingenuity as well as an understanding of physics related principles and is intended to stimulate interest in Science, Technology, Engineering, and Mathematics (STEM). The competition emphasizes the scientific and engineering practices found in the Next Generation Science Standards (NGSS) and participation in the competition integrated with appropriate instruction can address the Iowa Core.

The events include:

1. [Catapult](#)
2. [Mousetrap Car](#)
3. [Bridge Building](#)
4. [Soda Straw Arm](#)
5. [Measurement](#)

### **Contact Information**

#### State of Iowa Physics Competition

Questions related to the State of Iowa Physics Competition should be directed to Larry Escalada (319-273-2431 or [Lawrence.Escalada@uni.edu](mailto:Lawrence.Escalada@uni.edu)).

### **State Competition Definitions and Clarifications**

1. An **individual school** is defined as a building within a school district. If a school district has multiple high schools, each building is considered a separate individual high school.
2. A **school team** is defined as the group of all the students that one individual school brings. These students are grouped into event teams, which are elaborated on below. Each school team can have up to three event teams for each event. A school team may consist of a maximum of 30 students. All event teams from the same school may qualify in the preliminary round and compete in the final round for individual event medals. A school's highest scoring event team per event will be used to determine a school's overall competition score. A school team does not have to enter all events but a score of 0 will be entered in the team score for events in which 2 students fail to compete.
3. An **event team** is defined as one consisting of 2 students from the same school competing in an event. An event team must consist of two students. Each event team may enter only one device in each event.
4. Only those event teams that have qualified in the preliminary round may go on to the final round.

### **Device Rules**

1. Each school team will enter UP TO THREE DEVICES and each event team from each school will enter one device for each event.
2. All catapults, mousetrap cars, and bridges must be labeled with the names of the competing student(s) and school on a sticky note. After the dimensions of these devices have been checked and before the event begins, the devices must be turned in and not touched or manipulated by the participants.
3. Unless otherwise stated in the rules for each event, only that event's team members may manipulate the team's device during the event.
4. Accommodations will be allowed for participants with disabilities where a 3rd person will be allowed to move the device for that participant under the direction of the participant, if necessary. It is the responsibility of the coach or participant to inform the judges of accommodations ahead of time.
5. Each teacher will sign a compliance form certifying that their students constructed their own devices from scratch for the current year of competition, with only materials as specified in these rules, and without

the use of a commercial kit. It is the responsibility of the sponsoring teacher to assure student compliance with all of the applicable rules as well as appropriate moral and ethical behavior.

### Scoring - Final Round

Entries for all events in the preliminary round will not be formally scored to determine overall placement. Scoring in preliminary round will be used to determine qualification for the final round. In the final round, each event is scored separately with the top three places being declared for each event with medals provided for the top 3 event teams per event. **The overall school team score will be the sum of the 5 highest event scores with the three highest scoring school teams being awarded 1st, 2nd, and 3rd place trophies.**

### Individual Event Scoring

1. A single event team is awarded a maximum of 10 points for each event.
2. All event teams that enter and compete in an event without being disqualified will score a minimum of 1 point.
3. If fewer than 10 competing event teams, points will be awarded only for those places. If more than 10 teams compete, those in 10th place and lower each receive 1 point.
4. In the event of a tie, the event teams will share points from the 2 places. For example, tie for 2nd place, split 2nd and 3rd place with no 3rd place points awarded.
5. Event teams that enter a device in an event but receive a default, will have their place points divided equally between all the defaulting teams for that event.
6. Event teams that qualify for an event in the final round but do not enter a device in the final round, will receive zero points for that event. Each event is scored separately.
7. The overall school team score will be the sum of its highest event team scores across each event.

Placement	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th
Points Awarded	10 pts	9 pts	8 pts	7 pts	6 pts	5 pts	4 pts	3 pts	2 pts	1 pt

### Rulings and Appeal

In the case of any clarification or contention of an event or another team's entry, within one minute of being informed of the judges' decision or the completion of the other entry's trials respectively, a student team member may appeal to the event judges without outside influence or input (i.e. coaches, parents, other students, etc.). Any device ruled by the judges that does not comply with the rules will be given a time interval (determined by the judges) to be modified to comply. The resolution is up to the judges. The event judges may confer with head judges and/or competition director if necessary. **The decision of the judges is final.**

### Awards

Medals will be provided for the top 3 places for event teams in each individual event and trophies will be provided for the top 3 school teams overall in the final round.

## Schedule, Costs, and Information

### State Physics Competition

The State Physics Competition will be held on Tuesday, April 7, 2020 at the University of Northern Iowa (UNI) McLeod Center in Cedar Falls, IA with registration beginning at 8:30 am. The preliminary round for events will begin at 9:30 am with the final round in the afternoon of the competition to tentatively end by 4:30 pm. Information about the state competition including registration and compliance may be found [www.physics.uni.edu/outreach/uni-physics-olympics](http://www.physics.uni.edu/outreach/uni-physics-olympics). For questions related to the State Competition, call 319-273-2431 or email Larry Escalada at [Lawrence.Escalada@uni.edu](mailto:Lawrence.Escalada@uni.edu).

The cost for one school team is determined by the total number of students a school registers in the competition. The cost for 2 to 10 students is \$25. The cost for 12 to 20 students is \$45. The cost for 22 to 30 students is \$65. Completed registrations must be submitted and received by 11:59 pm on Friday, April 3, 2020. **No late registrations will be accepted.**

**All payments for the State Physics Competition** should be sent directly to the UNI Physics Department. Checks and P.O.'s will be accepted. P.O.'s can be sent to Becky Adams via email at: [becky.adams@uni.edu](mailto:becky.adams@uni.edu) or you can fax (319-273-7136), or mail the P.O. to Becky at: 215 Begeman Hall, Department of Physics, University of Northern Iowa, Cedar Falls, IA 50614-0150. Please use the same address for payment by check. For questions related to payment, contact Becky Adams via phone (319-273-2420) or email provided above.

# Events

## CATAPULT

---

**1. CATAPULT.** Each event team will submit one **stationary** "Catapult," built by both members to launch a ping-pong or table tennis ball from a starting line to 3 given targets. The device shall **NOT** exceed the following dimensions: **50 cm** in length, **40 cm** in width, and **60 cm** in height. Teams may place their devices in either cocked or uncocked position prior to the judges' measurements of the device's dimensions. Cocked position is defined as when the device is in "ready to fire" position. The energy sources shall consist of any elastic storage device (rubber bands, bungee cords, leaf springs, etc.) **and/or gravity-powered device**. No other mechanical or chemical device may provide energy the propulsion of the ball. The judges will provide the ping-pong balls. Once the catapults are found to be in compliance with the construction parameters, the students may not handle their catapults until they compete. **The students may activate the catapult by releasing a tripping mechanism or releasing the propelling device manually.**

**The Competition** –The official competition ping-pong ball will be a 40 mm table tennis ball. Teams will use ping-pong balls supplied by the judges. Each device will be placed behind a starting line. After being given the ping-pong ball to be placed on their device, teams have 1 minute to launch the ping-pong ball.

**\*Dimensions need to be met for both rounds.** Dimensions will be measured before the preliminary round. If the team advances to the final round, the bridge will remain at scoring table until the final round

### **Preliminary Round 1**

A target line will be marked on the floor **4 meters** from the **starting line**. Students will be given 3 ping-pong balls, and have three attempts to qualify for the next round. In order to advance, the team must land one of their ping-pong balls within **1 meter of the 4 meter target line**.

### **Preliminary Round 2**

A target line will be marked on the floor **2 meters** from the **starting line**. Students will be given 3 ping-pong balls to be used to qualify for the final round. The point where the ball first contacts the floor of each ball will be marked, and the position of the closest shot will be measured and recorded. The 10 event teams with the lowest distances will advance to the final round.

### **Final Round**

A target point will be marked on the floor 8 meters from the starting line. Each team gets two trials at this distance. The point where each ball first contacts the floor will be marked, and the distance measured radially from the center of the target to the marked point.

In each round of the competition, once students place the catapult behind the starting line, they will have a maximum of two minutes to launch the ping-pong balls. Exceeding the 2-minute time frame will result in a disqualification (Preliminary Round 1), or a default score of 2 meters (Preliminary Round 2) or **8 meters** (Final Round). No other students may enter the competition zone once the ping-pong balls have been given to the team.

## MOUSETRAP CAR

**2. MOUSETRAP CAR.** Each event team will enter one mousetrap-powered car designed and built by team members. The car shall not include any parts from a commercial mouse trap car kit. The objective is to have the car stop as close to a target line as possible.

### Car Design Requirements:

- Dimensions: **25 cm in length x 15 cm in width x 15 cm in height.** Teams may place their devices in either cocked or uncocked position prior to the judges' measurements of device dimensions. Cocked position is defined as when the device is in "ready to launch" position.
- Teams must clearly mark their designated front edge of the car and inform the judges of their front edge before any measurements are made by the judges. **Once identified with a permanent marker, this point may not be changed.**
- The car shall have a minimum of two (2) wheels in contact with the testing surface at all times. **If any portion of the device (other than a string) makes contact with testing surface during the trial, the device scored as a default of 500 cm. String may touch the surface at any given time without disqualification.**
- The sole power source of the car shall be a standard mousetrap (about 2" x 4") as a part of the car.
- No string, wire, materials, or system may be used to link the device to another object during the competition.
- Cars must be self-starting - no pushing for starts.



Design requirements will be measured before the preliminary round. If the team advances to the final round, the car will remain at the scoring table until the final round.

### Competition Field Requirements:

- The car must travel within a **200 cm** wide lane. The lane will also extend 50 cm before the start line to form a start zone. The front edge of the car must start within the designated start zone defined by the interior edge of the line.
- The target line will be located **500 cm** from the launch line.

### Preliminary Round - Competition Rules

- The car will be allowed **two trials** to determine the best distance.
- The car may be launched from any point within the 50 cm start zone.
- Once the competitor steps behind the launch line, there will be a maximum of two minutes to launch. Exceeding the 2-minute time frame will result in a default for that trial and will be scored as a default of **500 cm.**
- No false starts will be allowed. Cars must be self-starting - no pushing for starts.
- Any attempt in which the car breaks the plane of either side boundary width line will be declared a fault and given a result of **500 cm.**
- The distance recorded will be measured perpendicularly from the target line to the point on the front edge of the car that was designated by students for the judges during the check in process.
- A car stopping point can be on either side of the target line.
- A car must have at least one trial where the distance recorded is no greater than **100 cm** from the target line to allow the team to advance to the final round.

**Final Round - Competition Rules**

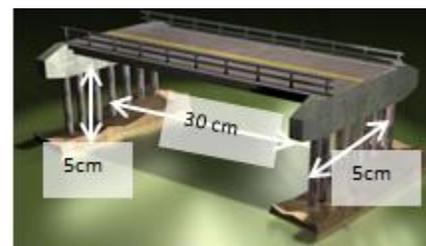
- a. The final round will be governed by all the requirements and rules listed above, excluding (h) under **Preliminary Round - Competition Rules**.
- b. The shortest perpendicular distance from the designated front edge to the target line determines the car with the best score. Other teams will be given a score based on a ranked order from shortest distance to longest distance. In the case of a tie between teams with their best distance, the results of the other trial score in the final round will break the tie for a score.

## BRIDGE BUILDING

**3. BRIDGE BUILDING.** Each event team will submit one toothpick bridge for testing, built by team members.

### Design Requirements

- a. The bridge will be constructed from Diamond or Forster flat, round, or square wooden toothpicks approximately 6.5 cm in length from a box labeled accordingly: Flat, Round, or Square Toothpicks; and **Elmer's™ white glue** may be used. **NO other glue may be used. Any off-white color for dried glue found on the bridge will result in a disqualification.**
- b. The bridge resting on a table should be constructed in such a way to provide clearance on its underside for a 5 cm x 5 cm x 30 cm board to pass under the bridge between its two supports as the board moves along table top with its 30 cm length parallel to the length of the bridge. See the illustration on the right to visualize the clearance that must be provided. The illustration, however, does NOT show a roadway that is within the required specifications for this event.
- c. The roadway of the bridge between the two supports, which is the location of the bridge on which the load will be tested (may or may not be the top of the bridge), shall be between 4 cm and 6.5 cm wide along the maximum length of the bridge and at a height from the tabletop of not more than 10 cm. The maximum length between the two supports is 44 cm.
- d. The roadway (see definition in part c) shall consist of at least a rail along each side, which is continuous along the maximum length of the bridge. It need not have a travelable surface.
- e. As a measure of how level or how flat the roadway is, a 1.9 cm (tall) x 3.5 cm (wide) x 50 cm (long) board is laid along the roadway. There cannot be more than a 1.0-cm vertical gap between the board and roadway on either end.
- f. During the preliminary round, the bridge shall allow for a flat board to be placed across the bridge on the roadway so that masses can be placed on the center of the bridge.
- g. The bridge shall allow for a test rod - a metal plate with the dimensions of 5 cm (wide) x 8 cm (long) connected to a metal rod of diameter 0.5 cm which passes through the bridge - to be placed perpendicularly **across the bridge on the roadway** and within 2 cm of the center of the roadway during the final round. During the final round, student teams may easily remove toothpicks from their bridge for the test rod to be placed at the discretion of the judges. Teams may or may not be allowed to remove significant sections of their bridge and re-glue any of their components depending on the discretion of the judges.
- h. The maximum bridge height shall be 20 cm from the lowest to the highest points of the bridge.
- i. The bridge must be "free standing".



**\*Dimensions need to be met for both rounds.** Dimensions will be measured before the preliminary round. If the team advances to the final round, the bridge will stay at the scoring table until the final round.

**Preliminary Round-** The bridge will be tested as follows:

1. The mass of the bridge will be measured by the judges.
2. The bridge shall be placed by the student(s) on a testing stand, which will consist of two flat surfaces level with respect to each other and separated by 25 cm
3. Students will place a flat board on the roadway on the bridge so the center of the board aligns with the center of the bridge
4. Masses will be placed on the center of the board on the bridge, until the total mass of the board and added masses equals or exceeds 10 times the measured mass of the bridge
5. The bridge must hold this mass for 10 seconds without failure that results from any added mass.
6. All teams with a bridge that supports the added mass for 10 seconds will move on to the final round of the competition.

**Final Round** - The bridges will be tested as follows:

1. The mass of the bridge be entered into the LoggerPro software program used in the testing. The bridge shall be placed on a testing stand, by the student(s), which will consist of two flat level surfaces level with respect to each other and separated by approximately 25 cm.
2. The testing apparatus will be placed over the bridge, by the student(s), with the test rod placed on the roadway as specified above. (Maximum bridge height is 20 cm.)
3. The students will indicate at what point to “zero” or pre-load the scale. **Students will make this call, NOT the judges.** No deflection or force prior to this point will be counted towards the final measurement. Once at the desired point, the sensors on the testing apparatus will be zeroed.
4. Force will continue to be applied slowly by the student via the testing apparatus to the test rod (by twisting the turnbuckle) while one scorer continuously calls the scale reading until the tester detects a deflection of 0.5 cm. The scale reading last called is the measured force applied or bridge strength.
5. The team with the **largest ratio of measured force applied divided by the mass of the bridge** will be declared the winner.

The Vernier Structures and Materials testing apparatus pictured to the right shows what will be used at the state competition.



## SODA STRAW ARM

**4. SODA STRAW ARM** - each event team will be given 12 jumbo plastic, clear straws, and 10 straight pins as well as one meter stick. The straws used in the competition will be 7 $\frac{3}{4}$ " or 10" straws. **Straws will be provided for the actual competition only. No straws will be provided for event preparation.** The purpose of the competition is, with only the above materials, to construct the longest arm, from a team's own design, that will support a 50-gram mass hanging from a 30 cm string and attached to the arm by a #1 smooth paper clip bent into an "S" shape. The mass must be hung by the paperclip (*i.e.* - it cannot be tied by the string directly to the arm) and the students cannot bend the paperclip to "wind" it around the straw. It may not be used in any way to strengthen or help construct the arm. Construction time will be **15 or 5 minutes, depending on the round of competition, with testing by the team allowed during the construction.**



**The Competition** - One of the team members will hold the arm in the desired test position against the tabletop with no part of the team member's body extending beyond the test edge of the table and with both palms touching the tabletop (hands flat against the table top). No other part of the body may touch the arm or be attached to it. No part of the straw arm may be pinched between two parts of the hand (*i.e.* the role of this person is to hold the straw arm **down onto the table**, not strengthen the structure of the straw arm). The other team member will attach the mass by placing the hook end of the paper clip holding string attached to the 50-gram mass over their arm. As soon as the team member hooks the string and immediately removes his/her hand from the string, the 10-second period will begin. This team member may not touch the arm, string, or mass during the 10 second time period. During this time the holding team member **may not manipulate** the arm. At the end of the 10-second time period, the judge will measure the length (from table edge to string).

### **Preliminary Round:**

- a. **Prior to the competition, students are required to bring and show the judges a sketch of their design which shall guide their construction.** No physical models will be allowed at the competition. If no sketch is provided, this will result in a disqualification.
- b. Straws, pins, the mass and a meter stick will be provided at the competition. The mass will be attached to a string (approximately 30-cm from the paper clip to the top of the mass). Scissors, pliers, chemical splash goggles, protective (not rubber/plastic) gloves, wire cutters, and a ruler will be allowed as tools but they will NOT be provided. These tools and the sketch are the only items the team may bring to the table.
- c. **If students wish to cut pins, they must bring and wear chemical splash goggles and gloves and move to the "pin cutting station" to complete this process. Goggles, protective gloves (not rubber or plastic), and wire cutters will NOT be provided.** Students will not be allowed to cut pins without wearing goggles and protective gloves.
- d. All construction must be done during one **15-minute** time period at the competition site. If pins bend or break during construction, they will not be replaced. At the end of the **15-minute** period all work on the arms must end. Competitors will be asked to leave their arm on their table and step away from the tables. The team members will pick up the arm only when they are called to compete. **No modifications are allowed after the 15-minute construction period.** This prohibition includes replacing straws or pins which have pulled loose from the arm.
- e. The arm apparatus must be in contact with (not secured to) the top surface only of the table.
- f. The arm must support the mass *above the floor* for 10 seconds without any straws "crimping". Crimping is a fold line across the straw and will be allowed in the original construction before testing. Crimping will

be treated the same as a weight hitting the floor and the team will receive a default score.

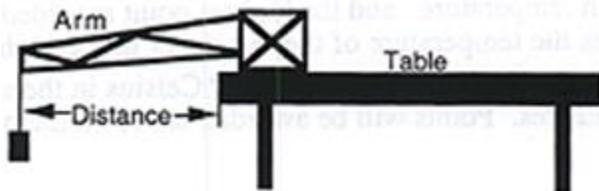
g. A team member is responsible for holding the straw arm and sliding it out from the edge of the table to the desired position. This person may not touch any part of the apparatus that extends beyond the table once timing has begun. Once the straw arm is in the selected position and tension has been supplied by the 50-gram mass, the 10-second period begins, and all manipulation of the arm by the holder must stop.

h. The distance will be measured along a horizontal line perpendicular to the table edge from the point directly above the point of attachment of the weight. The distance must reach at least 25 cm to qualify for the next round. A 25 cm mark will be placed on the floor with masking tape.

i. If the arm design is such that the arm end is higher than the tabletop, the 30 cm string must extend below the top of the table so the judge can accurately measure the length using a meter stick at table-top height. Any straw arm that can hold a mass of 50 grams for 10 seconds and reaches a length of 25 cm will advance to the next round.

j. If the arm holds the mass above the floor without crimping for a full 10 seconds but the length is less than 25 cm, the team is awarded an immediate second trial. No changes may be made to the arm except for desired repositioning on the tabletop.

k. All arms which make it to the final round will be kept by the judges until the final round.



### **Final Round:**

a. **Teams that advance to the final round will be given 5 minutes to improve construction of their arm. They will also be given an additional 5 straws and 4 pins.** The preliminary building rules apply (i.e. safety equipment is required for cutting pins).

b. All construction must be done during the **5 min** time period at the competition site. If pins bend or break during construction, they will not be replaced. At the end of the **5 min** time period all work on the arms must end. Competitors will be asked to leave their arm on their table and step away from the tables. The team members will pick up the arm only when they are called to compete. **No modifications are allowed after the construction period.** This prohibition includes replacing straws or pins, which have pulled loose from the arm.

c. The arm apparatus must be in contact with (not secured to) the top surface only of the table.

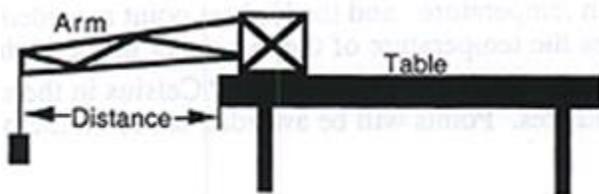
d. The arm must support the mass *above the floor* for 10 seconds without any straws "crimping". Crimping is a fold line across the straw and will be allowed in the original construction before testing. Crimping will be treated the same as a weight hitting the floor and the team will receive a default score.

g. A team member is responsible for holding the straw arm and sliding it out from the edge of the table to the desired position. This person may not touch any part of the apparatus that extends beyond the table once timing has begun. Once the straw arm is in the selected position and tension has been supplied by the 50-gram mass, the 10-second period begins, and all manipulation of the arm by the holder must stop.

h. The distance will be measured along a horizontal line perpendicular to the table edge from the point directly above the point of attachment of the weight. The distance to be recorded will be the distance at the end of the 10-second time period.

i. If the arm holds the mass above the floor without crimping for a full 10 seconds but the length is less than 40

cm, the team is awarded an immediate second trial. No changes may be made to the arm except for desired repositioning on the tabletop.



- j. If the arm design is such that the arm end is higher than the tabletop, the 30 cm string must extend below the top of the table so the judge can accurately measure the length using a meter stick at table-top height.
- k. The winner is the team with the arm having the longest recorded distance, which held the mass successfully for 10 seconds.

## MEASUREMENT

---

The goal of this event is to measure the height and/or length of some specified object or distance; the distance will always exceed 10 meters. Prior to the event, the object and/or distance will be determined by the judges and will be considered the accepted value. All teams that score in the top 50% of the preliminary round will qualify for the final round. The top scoring team in the final round will be declared the contest winner.

### Rules

1. **Equipment:** The following equipment shall be supplied by the event organizers: 30-cm rulers, meter sticks, protractors, stopwatches, string in varying lengths (not to exceed 2 meters), and tape.
2. Teams may use any other equipment of their choosing with the exception of range finders, distance measuring apps, and other electronic measurement systems. Equipment used may not exceed 2 meters in length for any single dimension. All equipment brought by teams must be checked by the judges prior to use, and the judges have the right to disqualify any equipment deemed unfair to competition.
3. Teams should list all equipment used on the event score sheet which is provided at the end of the rules for this event.
4. Teams should briefly describe (1-3 sentences) the technique used to perform the measurement on the event score sheet.
5. Teams must measure the specified distance a minimum of three times, and report the average of all good measurements as their best estimate.
6. Teams should calculate the standard deviation of all measurements, and report this value as the experimental uncertainty. Teams may use calculators, computers, or other tools to calculate averages and standard deviations.
7. Failure to report tools, technique, or all measurements results in not earning the associated credit. Judges may, at their discretion, award partial credit for these sections provided the same criteria are used for all submissions.
8. Failure to report either or both of the measurement or uncertainty values will result in a team's disqualification.
9. The score of the measurement must be a measure of the closeness to the accepted value, as well as the precision of the measurement. The following formula will be used to evaluate this score:

$measurement\ score = 100 - fractional\ absolute\ error - fractional\ uncertainty - statistical\ success$

where

$$fractional\ absolute\ error = \frac{|real\ value - best\ estimate|}{real\ value} \times 100$$

and

$$fractional\ uncertainty = \frac{measurement\ uncertainty}{best\ estimate} \times 100$$

and

$statistical\ success$

$$= |high\ estimate - real\ value| + |real\ value - low\ estimate| \\ - (high\ estimate - low\ estimate)$$

The larger the uncertainty, the more likely it is that the measurement will include the accepted value. On the other hand, the larger the uncertainty, the less valuable the measurement is.

Using this formula, a team that produces an estimate that is closer to the accepted value AND has smaller uncertainty in their measurements will get a higher score, provided that the accepted value lies within the reported uncertainty of the reported estimate. The highest possible score of the measurement is 100.

### Preliminary Round

1. The preliminary round of competition will commence at the beginning of the Physics Competition. Teams may begin the event at any time up until 11:00 a.m. (30 minutes before the preliminary round deadline.) The measurement should be completed within approximately 30 minutes, but the contest time window is open to provide flexibility to teams competing in other events.
2. Competing teams will be given a score sheet and the object and/or distance to be measured will be specified.
3. The measurement contest concludes at 11:30 a.m. All score sheets entered in the contest must be received by the judges by 11:30 a.m. in order to be considered; late entries will not be scored.
4. The top ten teams (by total score) will advance to the final round of the competition.

### Final Round

1. The final round of competition will tentatively commence at 1:00 p.m.
2. Competing teams will be given a new score sheet, and the new object and/or distance to be measured for the final round will be specified.
3. The final round of the measurement contest tentatively concludes at 2:00 p.m. All score sheets entered in the contest must be received by the judges by 2:00 p.m. in order to be considered; late entries will not be scored. (If start and finish times are altered, schedules will be provided to all teams on the day of the competition.)

4. The top scoring team will be event winner; numerical scores will be used in descending order to determine 1st - 10th place.

## Measurement Contest Score Sheet

Preliminary Round

Final Round

School Name: \_\_\_\_\_

Team Members Names: \_\_\_\_\_

Object or distance measured: \_\_\_\_\_

**Tools** [5 pts]: *Please list all tools used to perform any measurements or calculations*

**Procedure** [10 pts]: *Please briefly describe the procedures and calculations used to determine your measurements.*

**Measurements** [10 pts]: *Please list all individual measurements of the object and/or distance; you must have a minimum of three independent measurements.*

**Best Estimate** (The average of all reasonable measurements): \_\_\_\_\_

**Uncertainty** (The standard deviation of all reasonable measurements): \_\_\_\_\_

*Judges Use Only*

**Measurement Score:** \_\_\_\_\_/100      **Total Measurement Contest Score:** \_\_\_\_\_/125

**IOWA PHYSICS COMPETITION  
2019-2020**

**Judge and Event Director Checklists**

**CATAPULT Checklist**

1. Check each device to assure that **only** elastic storage device (rubber bands, bungee cords, springs) and/or a gravity powered device are used.
2. Check for size compliance of the device with the following dimensions: **50 cm (l) x 40 cm (w) x 60 cm (h)** in cocked or uncocked position. Note that cocked position is defined as “ready to fire”.
3. Complete 1 and 2 above for all contestants before proceeding with the preliminary round.
4. After each device has been checked in, place it on a table and **assure that students do not handle the device** until it is time for that team to compete.
5. Mark the point where the ball first contacts the floor for the appropriate distance in the preliminary and final rounds.
6. After each event team completes their first preliminary round attempt, determine whether their ping-pong ball is within 1 meter of the 4 meter target line.
7. After each event team completes their second preliminary and final round attempts, measure and record the distance from the center of the target to the point of the ball contact with the floor.
8. Students will have a maximum of two minutes to launch a ping-pong ball in each round of the competition. Exceeding the 2 minutes time frame will result in a disqualification (Preliminary Round 1), or a default score of 2 meters (Preliminary Round 2) or a default score of 8 meters (Final Round).
9. **Please make sure that the three table tennis balls (40 mm) official ping-pong balls are ready.**

**IOWA PHYSICS COMPETITION  
2019-2020**

**MOUSETRAP CAR Checklist**

1. Check for size compliance of the device with the following dimensions: **25 cm (l) x 15 cm (w) x 15 cm (h)** in either cocked or uncocked position. Cocked position is defined as when the device is in “ready to launch” position.
2. Check that students have marked with a permanent marker the front edge of their car that will act as the point from which measurement(s) will be taken and told you the location of the front edge prior to any measurements being made.
3. Complete 1 and 2 above for all contestants before proceeding to the preliminary round. After each car has been checked in, place it on a table and **assure that students do not handle the car** until it is time for that team to compete.
4. For each trial, the front edge of the **entire device (including the wheels)** must start within the designated “start zone” defined by the interior edge of the tape.
5. As each car competes, the front edge of the car designated by the students is immediately marked by tape on the floor and the distance is measured to the closest edge of the line. The distance will be measured perpendicularly from the target line to the point on the front edge of the car. A car stopping point can be on either side of the target line with the team’s designated front edge to be measured from this line.

**IOWA PHYSICS COMPETITION  
2019-2020**

**BRIDGE BUILDING Checklist**

1. Check that the only **construction materials** are flat, round or square wooden toothpicks; and Elmer's white. **NO other glue allowed.**
2. Determine whether the bridge is “free standing”.
3. Measure the **mass** of each bridge.
4. Check for the **under bridge clearance** with the provided gauge of a **5 cm x 5 cm x 30 cm board**.
5. Check the **roadway height** (not more than 10 cm above the tabletop) and the **roadway width** (between 4 cm and 6.5 cm). Check that the roadway has a **continuous rail** along the **maximum length** of the bridge.
6. Check that the **length** between the two supports shall not exceed 44 cm.
7. Check the **height of the bridge** shall not exceed 20 cm from the lowest to the highest points of the bridge.
8. Check to see if the roadway is level or flat **with the board provided**. (no more than 1.0 cm gap at either end).
9. Check that the **roadway** will allow for a flat board to be placed so **masses can be placed on the center**.
10. Check for the **placement of the test rod** - metal plate with dimensions of 5 cm (wide) x 8 cm (long) connected to a metal rod of diameter of 0.5 cm which vertically passes through the bridge to be placed perpendicularly across the bridge on the roadway and within 2 cm of the center of the roadway during the final round. Students may remove toothpicks from their bridges for the test rod to be placed at the discretion of the judges.
11. After each bridge has been checked in, place it on a table and **assure that students do not handle the bridge** until it is time for that team to compete. Bridges must be clearly labeled or marked with student/team names.
10. In the preliminary round, supervise each event team as they place a mass and board that is 10x the measure mass of their bridge. Bridge must hold this mass for 10 seconds without failure to move on to the final round.
11. **Supervise as student(s)** test each bridge for force applied or bridge strength. *The students will indicate at what point to “zero” or pre-load the scale.* The event director should **verbally call out the reading of the the Force plate** at each 1.0 N or agreed upon kg N (by the judges) increment. The recorder should watch for tester reaches the 0.5 cm deflection and then record the largest kg, lb, or N reading as the bridge strength or measured force applied.
12. Determine the ratio of the measured force applied over mass of the bridge. The highest ratio of bridge strength to mass of bridge will be designated the winner.

**IOWA PHYSICS COMPETITION  
2019-2020**

**SODA STRAW ARM Checklist**

1. **Students are required to bring and show the judges a sketch of their arm design prior to the start of the event for both preliminary and final rounds.** Make sure there are **no model arms brought with student teams.** A team with no sketch will be disqualified from the event.
2. **Distribute** the straws and pins. It is recommended that the students be given several minutes to count the pins and straws and also to exchange any items they consider defective. Then **start timing.** Notice that students may provide their own gloves, goggles, scissors and/or pliers only. Other tools should not be allowed.
3. If students wish to cut pins they must bring and wear chemical splash goggles and gloves and move to the “pin cutting station” to complete this process.
4. At the end of **15 minutes** call time for the preliminary round and **5 minutes** call time for the final round, collect and label all arms and place them on a table.
5. After each arm has been checked in, place it on a table and **assure that students do not handle the arm** until it is time for that team to compete.
6. As each arm is tested, **check** for appropriate positioning and use of **hands while sliding and holding.**
7. If an arm holds the mass on the first trial the team is immediately given a second trial. If the arm does not hold the mass on the first trial the team receives a fault and **does not get a second trial.**
8. Measure and record the **length** of each arm. Circle the length for the top five teams.

**IOWA PHYSICS COMPETITION  
2019-2020**

**MEASUREMENT Checklist**

Before the event starts

1. Determine the accepted value for the measurements to be used in the preliminary and final rounds.
2. Make sure that all teams have access to the same equipment supplied by the event organizers.
3. Identify all event teams. Each team must have 2 students. Provide each competing team with a Measurement Contest Score Sheet.
4. Check any equipment brought by each event team to determine whether it can be used. No range finders, distance measuring apps, and other electronic measurement systems may be used. No single dimension of any equipment used may exceed 2 meters in length. Teams may use calculators, computers, or other tools to calculate averages and standard deviations. It is at the judges discretion to disallow other types of equipment, as long as expectations across teams remain uniform.

During the event in preliminary and final rounds

1. Event teams should need approximately 30 minutes to complete the event, but the contest time window is open to provide flexibility to teams competing in other events. As such, at least one judge should remain at the Measurement Contest station at all times during the event window to check in competing teams, and receive score sheets.
2. As far as possible, ensure that teams do not copy from one another.
3. Make sure that the teams do not alter any provided equipment.

Collecting student results

1. When an event team finishes, collect their score sheet. Ensure that all sections are filled out. Also, ensure that an uncertainty value (standard deviation of all measurements) is reported. Teams not including uncertainty values are disqualified.
2. Using the provided formulas, calculate the measurement score score for each team. (*A spreadsheet for automating calculations of the measurement score can be obtained from Jeff Morgan ([jeff.morgan@uni.edu](mailto:jeff.morgan@uni.edu))*) The maximum measurement score is 100.
  - a. Note that if the accepted value lies within the reported uncertainty of the reported best estimate, the statistical success will be 0. (This portion was added to penalize teams when the “real” value lies outside of reported uncertainty, and to discourage teams from reporting unreasonably small uncertainties.)
3. Award points for descriptions of tools used, measurement technique, and inclusion of all measurements. Calculate the total score (with a maximum of 125 points.)
4. Preliminary round: Rank all entries in descending order of scores achieved. Teams within the top 50% of the preliminary round scores advance to the final round.
5. Final round: Rank all entries in descending order of scores achieved. The team achieving the highest score will be considered the event winner.