THE FORTIETH UBC PHYSICS OLYMPICS RULE BOOK

March 10, 2018

Financial sponsorship is provided by
Department of Curriculum and Pedagogy (Science Education Group)
Department of Physics and Astronomy

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General Rules

Each school, combination of schools, or (with permission) mini-school, may enter up to 15 students to compete in the 6 events in teams of up to 5. A school may request to have 2 teams, but each must have at least 4 students on the competition day or they will be combined into one team. Events are designed so undersized teams are not penalized. Each event is run in 6 heats lasting about 1 hour each. There is a break for lunch (not provided, but the Student Nest building is across the street from the Hennings Building). Gold, Silver, and Bronze medals will be awarded to the members of the top teams in each event. Plaques will be awarded to the schools with the top 6 combined scores, and a travelling trophy will be awarded to the top school.

The combined score of a team is the sum of their decibel scores in the 6 events. For each event, schools are ranked by their event score, and the corresponding decibel score for that event is given by $dB=10 \times \log_{10}(\text{rank})$. For example, a first place ranking in an event is 0 dB, second is 3.01 dB, fifth is 6.99 dB, tenth is 10 dB, and twentieth is 13.01 dB. The overall winner will be the school with the lowest total decibel score.

Interpretation of Rules

Normal physics interpretations will be applied to all the terminology used in defining the challenges. Those solutions that, in the opinion of the event judges, do not comply with the spirit or intent of the rules will be disqualified from the event (and thus ranked last for the event). The ruling of the event judges is final.

Pre-Build Events

There are two pre-build events, for which teams are required to design and build devices before the start of the pre-build events and to use the devices during those events. Pre-built devices will be checked into a storage room until required for a heat. Modifications are not allowed after arrival, except to repair damage sustained in transit.

The pre-built events are intended to be learning experiences for the students, so we ask that team coaches do not overly involve themselves in device design and construction.

Winning solutions will typically push up against the limits of the rules, but violating the rules will result in disqualification. To avoid this disappointment, teams are encouraged to contact the Physics Olympics organizers for a preliminary evaluation whether their design is within the rules. However, the ruling of the event judge about the legality of a pre-built device at the time of the competition is final, and overrides any preliminary evaluation.

Please direct inquiries about the rules to Prof. Aaron Boley, preferably by email to acboley@phas.ubc.ca or by telephone 604-822-3853, Monday-Friday 10 AM and 4 PM.

1. Ballpoint Pen Top

Your objective is to design and build a spinning top out of a ballpoint pen. The top that spins for the longest period of time will win.

1) Top Construction:
   a) The top can be built out of any non-hazardous material, except as follows:
      i) Pre-manufactured tops may not be used.
      ii) Tops may not include lighter-than-air gases.
   b) All designs must use a 1 mm, round stick ballpoint pen for the axis of the top. Examples of this type of pen can be found here:
      i) https://www.staples.ca/en/BIC-Round-Stic-Ballpoint-Pens-Medium-Tip-1-0mm-60-Pack/product_SS2122869_1-CA_1_20001
      ii) https://www.staples.ca/en/Stick-Ballpoint-Pens-1-0mm-Assorted-50-Pack/product_506127_1-CA_1_20001
   c) The top must spin on the tip of the ballpoint pen.
      i) The entire top must spin as a rigid body (no bearings).
   d) Only minor alterations to the body of the ballpoint pen are allowed, such as making small holes or slots for constructing the entire top. Adhesives may also be used, except on the tip of the pen. Disqualifying alterations include the following:
      i) modifying the tip of the pen in any way;
      ii) cutting the pen into multiple pieces, even if re-attaching those pieces; and,
      iii) shortening the pen.
   e) The fully-constructed top may not exceed 30 cm in diameter or height.
   f) The top's centre of gravity must be at least 1 cm above the tip of the ballpoint pen, measured upward from the tip along the spin axis.
   g) The use of external forces to stabilize the top (e.g., magnetism) is prohibited.
2) Spinning Surface:
   a) The top must spin on the bowl-shaped bottom of an inverted 355 ml Canada Dry ginger ale pop-can[1] (see Figure 1). Any standard 355 ml pop-can may be used in lieu of Canada Dry.
   b) The judges will provide an unaltered pop-can that will be fixed to a base (e.g., a 30 cm by 30 cm, Figure 2).
   c) Teams may also choose to provide their own pop-can. If this option is selected, the pop-can must be unaltered, other than drained (if desired), and must be fixed to a base or incorporated into a spin-up device (see Part 3). It is permissible to fill a drained can with another material, provided that the shape of the can is unaltered and that the material does not interact with the spinning top.

[1] We chose to hyphenate *pop can* to avoid confusion between *can* and other verbs.

d) The pop-can may not be held while the top is spinning, except during spin up and before timing begins.

3) Spinning up the Top:
   a) The top may be spun up by either a simple hand twist or by using a spin-up device.
   b) If the team chooses to use a hand twist, then the top may only be spun by one person and that person may only use one hand. For the hand twist, no additional materials may be used (e.g., pulling by hand a string wrapped around the top).
   c) Instead of a hand twist, a spin-up device may be used, provided it meets the following specifications:
      i) The top must be spun up using the energy released from a falling weight. No additional sources of energy are permitted. The launch device may not be combined with a hand twist.
      ii) A 1 kg weight will be provided by the judges (Figure 3). The weight will have a hook on top for quick incorporation into the team's launch device.
      iii) The weight may be dropped a vertical distance no larger than 1.8 metres.
      iv) The pop-can and its base must be placed on a table with a tabletop height of 1 metre and tabletop dimensions of 60 cm by 76 cm. The table will be provided by the judges.
      v) The pop-can may be integrated with the launch device, provided the system is compliant with Part 2.
      vi) Parts of the launch device may be held or steadied by hand.
      vii) Team members may not directly touch the top during spin up.

4) Scoring:
   a) The top that spins for the longest time will win.
   b) Time begins when the top has been spun up and is no longer touching a team member (for a hand twist only) or any part of the spin-up device.
   c) Time ends whenever the top stops spinning or whenever any part of the top, except the tip, comes in contact with the can, the launch device, the table, or any other object. Time will also end whenever the tip of the pen leaves the pop-can, other than during momentary skips.
   d) In the event of a tie, the top with the highest centre of gravity will win.

Figure 1: The bowl-shaped bottom of an inverted 355 ml Canada Dry ginger ale pop-can.

Figure 2: Canada Dry cans fixed to 30 cm by 30 cm plywood boards.

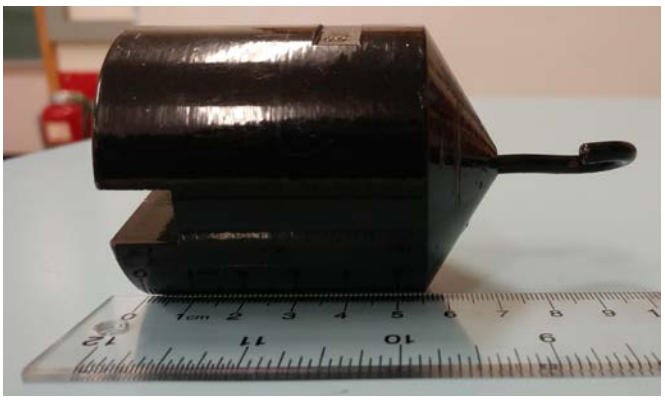

Figure 3: 1 kg weight with a hook on top.

Major amendments to Ballpoint Pen Top preliminary rules

To be aware of all changes, we encourage teams to read through the complete rules.

Added: Part (1), section (c), subsection (i)
Added: Part (1), section (g)
Modified: Part (2), section (c). Filling the pop-can with a substance if drained.
Modified: Part (3), section (c), subsection (iv). Tabletop dimensions now stated.
Modified: Part (4), section (c). Stopping of time now includes the top's tip leaving the can.
Added: New Figures 2 and 3.

2. Vinegar and Baking Soda-Powered Ballistics

Your objective is to launch a projectile a predicted distance using the pressure produced by mixing vinegar and baking soda. The team that best maximizes projectile distance and accuracy will win.

1) Launch Device Construction:
   a) Teams must build a launch device that mixes vinegar and baking soda and then uses the resulting gas pressure to launch a projectile.
   b) The launch device may be built out of any non-hazardous material. Care should be taken to ensure that the vinegar will not react with materials or adhesives used to construct the launch device.
   c) The device must be designed and built by the team. Pre-manufactured devices will be disqualified. Device components that are pre-manufactured may be used.
   d) The launch device can be incorporated into the projectile itself.
2) Vinegar and Baking Soda Quantities
   a) The judges will provide each team with 60 grams of white distilled vinegar (5% acetic acid by volume) and 36 grams of baking soda. Teams are not required to use the entire amount of vinegar or baking soda. Water will also be provided.
   b) The baking soda and vinegar must be placed into the device during each team's competition time (Part 8).
   c) Only the vinegar and baking soda provided by the judges may be used in the device for reaction. Any additional pre-loaded vinegar, baking soda, or any other reactive agent will result in a disqualification.
   d) It is permissible to use water to aid in the launch, if desired. If water is used, then the team must use the water provided by the judges.
   e) Teams may bring their own measuring measuring tools for placing the desired mixture of vinegar and baking soda into the device. A scale, Dixie cups, a 100 ml graduated beaker, and kitchen measuring spoons (1 tablespoon, ½ tablespoon, 1 teaspoon, ½ teaspoon, and ¼ teaspoon) will be available, if desired.
3) Projectile Construction:
   a) The projectile may be constructed out of any non-hazardous material.
   b) The projectile should not pose any unreasonable risk to competitors, judges, or audience members.
   c) Projectiles must be able to mark where the projectile lands with a washable material, such as washable marker ink, washable paint, etc. The landing surface should be assumed to be plastic.
4) Proving Grounds and Flight Trajectory:
   a) The proving grounds consist of a launch zone, a hoop, and a landing zone.

b) The hoop is a hula hoop that is 85 cm in diameter. The bottom of the hoop will be placed 60 cm above the floor.
c) All projectiles must go through the hoop to score.
d) Projectiles may be launched from any location within the launch zone, shown in Figure 4.
e) The vertical distance from the floor to the tip of the projectile, as staged for launch, cannot exceed 45 cm.
f) Upon passing through the hoop, the projectile must land within the landing zone (Figure 4).

5) Range Prediction
   a) The range of the projectile is the perpendicular distance from the base of the hula hoop to where the projectile landed within the landing zone. The distance between the launch device and the hula hoop (i.e., within the launch zone) is not included in the range.
   b) Prior to launch, each team must inform the judges the range that their projectile will travel. The judges will write down this prediction, and the team members will initial the prediction to verify that the judges wrote down the correct range.
6) Projectile Launch:
   a) The projectile may only be powered by gas pressure due to combining vinegar and baking soda. The use of any additional energy source (e.g., human, gravity, spring) will disqualify the team.
   b) Team members may handle and manipulate the launch device, including initiating the reaction and/or triggering the launch, as long as the device is supported, in part, by the floor.
7) Scoring:
   a) Team scores are based on both projectile range and accuracy, as compared with the team's prediction.
   b) Scoring is assigned as follows:
      i) One point is awarded if the projectile passes through the hula hoop.
      ii) If the projectile lands in the landing zone, additional points are awarded according to $X/\Delta X$, where X is the actual range and ΔX is the absolute difference between the predicted range and the actual range. Distances are measured in centimetres, and the minimum allowed ΔX will be 1 centimetre. As an example, assume that a team launches a projectile that passes through the hula hoop and has a range of 600 centimetres. If the team had predicted a distance of 500 centimetres, then the score would be 7.
   c) Each team is responsible for ensuring that their projectile leaves a recognizable mark in the landing zone. Judges will also serve as spotters for the first-contact point of the projectile. In the event that a mark is not made or is not recognizable, the judges will use the spotted distance and apply a 1 point deduction.
8) Time and multiple attempts:

a) Each team will have 4 minutes to prepare and launch their projectile. If a launch does not occur within this time period, then the team will be disqualified. Additional time may be awarded at the discretion of the judges should complications exist beyond the control of the team.
b) Each team may have a second launch attempt, provided the attempt can be made within the 4-minute window. Only the last launch will be scored.

9)

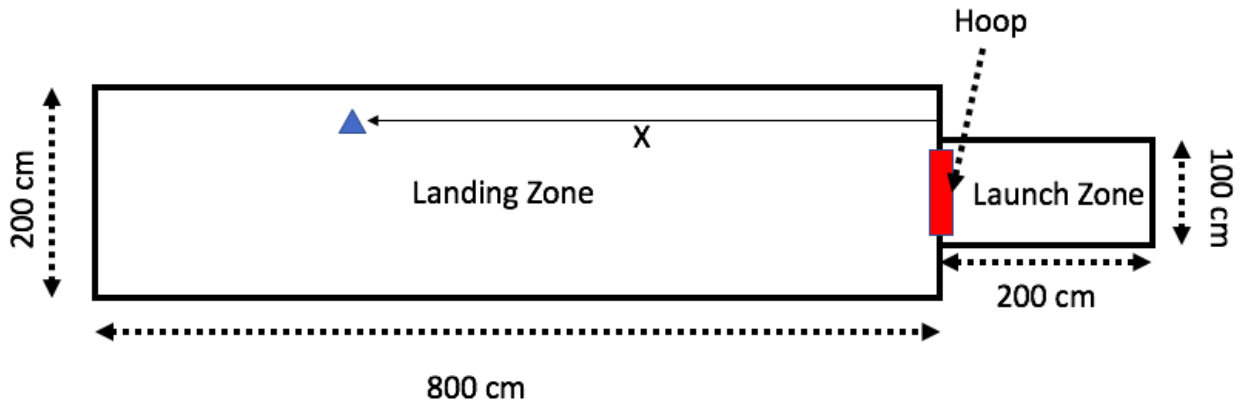

Figure 4: Proving grounds for the ballistics pre-build. All projectiles must start in the launch zone, pass through the hoop, and then land in the Landing Zone. The projectile range is the distance measured perpendicular to the base of the hula hoop. For example, if a projective were to land at the location of the blue triangle, then the range would be given by the distance X.

Major amendments to Vinegar and Baking Soda-Powered Ballistics preliminary rules

To be aware of all changes, we encourage teams to read through the complete rules.

Added: Part (1), section (d)
Modified: Part (2), section (a). Notes water will be provided.
Modified: Part (2), section (c). Changed language to emphasize reaction.
Added: Part (2), section (d). Use of water.
Modified: Part (2), section (e). Old part (2), section (d) is now part (2), section (3).
Modified: Part (2), section (e). Lists measuring equipment.
Modified: Part (3), section (c). Clarification on landing surface.
Modified: Part (6), section (b). Clarification on handling.
Modified: The old Figure 2 is now Figure 4.

3. Polarization Lab

A laboratory-based event involving polarization of light. Heats (except the last) will be closed to all persons except the participants.

4. Springs Lab

A laboratory-based event involving springs, oscillations, and Hooke's law. Heats (except the last) will be closed to all persons except the participants.

5. Quizzics!

Team members will work together to answer questions about physics and astronomy. Questions may involve mechanics, waves, electricity and magnetism, optics, fluids, modern physics, famous scientists, or the history of science. Some questions may involve short calculations. Use of cellphones or other wireless devices will result in disqualification.

All teams will participate in the preliminary Quizzics! heats. Questions are in multiple-choice format and each team will answer using an electronic clicker. Consultation between team members is allowed. The same questions will be used in each preliminary heat, so these heats are closed to all except the participants.

The teams with the highest scores in the preliminary heats will meet in the public round of Final Quizzics! using a buzzer system. Each question will be answered by the first team to buzz. For the first question, the correct answer (indicated by holding up a letter card) is worth 1 point, while an incorrect answer (or failing to hold up a card within 5 seconds) loses 2 points. For the second question, a correct answer is worth 2 points, and an incorrect answer loses 3 points. For question N, a correct answer is worth N points, and an incorrect answer loses N+1 points. The winner is the team with the maximum number of Final Quizzics! points.

6. Fermi Questions

The great twentieth century physicist Enrico Fermi was famous for being able to estimate anything to within a factor of ten. Examples of "Fermi Questions" are:

- What is the total mass of the students competing in the Physics Olympics today?
- How many litres of gasoline are consumed in Greater Vancouver each year?
- How many molecules of air are there in this room?

For more examples, look on the web. These were taken from
http://www.physics.uwo.ca/science_olympics/events/puzzles/fermi_questions.html

Answering a Fermi question in physics requires common sense understanding, knowing the order of magnitude of key constants of nature and physical parameters, and the ability to do approximate calculations quickly.

Your team will be given a number of Fermi Questions to answer using only pencil and paper and your own knowledge. No notes, tables, or books are allowed. No calculators, computers, tablets, cellphones, or other wireless devices are allowed. Since there will be a substantial number of questions to answer and only a limited time to answer them, speed and teamwork will be important. Your written answers will be graded for accuracy appropriate to the questions. Your answers must include appropriate units, in the SI (MKS) system. The same questions will be used in each heat, so these heats (except the last) are closed to all except the participants.

Many physicists pride themselves on knowing various constants of nature and physical parameters to at least one decimal place. Parameters that may be needed, to this accuracy, include but are not limited to:

the speed of light
Planck's constant
Boltzmann's constant
Avogadro's number
the mass of the electron
the mass of the proton
the charge of the electron
the constant in Coulomb's Law
the constant in Newton's Law of Gravity
the acceleration of gravity on Earth
the radius of the Earth
the distance to the Sun