2023 Physics Olympics RULEBOOK

UBC Physics & Astronomy

2023 UBC Physics Olympics Code of Conduct

By participating in the 2023 UBC Physics Olympics, participants agree to the Physics Olympics Code of Conduct. Any participant unable to adhere to the code of conduct will be dismissed from the event immediately; we reserve the right to limit that individual's participation in future events.

Our goal is to maintain a safe, positive, fun and challenging environment within an academic department where Physics Olympics participants can feel respected and capable. If we are to achieve this goal, it is necessary that all participants behave appropriately and respectfully towards event judges, volunteers, and other student participants.

We ask all participants to:

• Follow activity rules and instructions from the UBC Physics Olympics team.

• Treat each other with respect – be respectful of the rights and opinions of others, even if you don't agree with each other.

• Stay on topic – remember the objectives of the UBC Physics Olympics.

• Remember everything you share in the online platform is public – avoid sharing private and personal information (e.g. email address, home address or phone number for yourself or others).

• Review all rules and guidelines, and acknowledge that there are some risks involved in your participation in the program.

• Take steps to protect your own safety during the participation of any UBC Physics Olympics activities.

We will not tolerate any of the following:

• Cheating or other forms of academic misconduct.

• Speech that promotes discrimination based on race, sex, religion, nationality, disability, sexual orientation or age.

• Defamatory, indecent, hateful, deceitful, threatening, abusive, obscene, inflammatory, or

inappropriate comments.

• Messages that encourage or suggest illegal activity, contain sexually explicit material, contain advertising or promote any services, or are off-topic, unintelligible or irrelevant.

If you have any questions regarding the community guidelines or are experiencing harmful behaviours, please contact:

• Kirsty Dickson communications@phas.ubc.ca

• Marina Milner-Bolotin marina.milner-bolotin@ubc.ca

Rule Book for the Forty-Fifth
UBC Physics Olympics

Version 1

Released, 3 February 2023

The 2023 UBC Physics Olympics will be on Saturday, March 4, 2023, at UBC

Announcements related to Physics Olympics will be posted on Canvas; please check regularly for updates.

Department of Curriculum and Pedagogy (Science Education Group)

Department of Physics and Astronomy

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Objective:

UBC Physics Olympics strives to establish an intellectually challenging, exciting, positive, fun, and safe environment, wherein all participants feel engaged, respected, and capable of doing physics.

1. UBC Physics Olympics Code of Conduct

By participating in the 2023 UBC Physics Olympics, participants agree to the Physics Olympics Code of Conduct. Any participant unable to adhere to the code of conduct will be dismissed from the event immediately; we reserve the right to limit that individual's participation in future events.

We ask all participants to:

- Follow activity rules and instructions from the UBC Physics Olympics team.
- Treat each other with respect – be respectful of the rights and opinions of others, even if you don't agree with each other.
- Stay on topic – remember the objective of UBC Physics Olympics.
- Remember everything you share on online platforms could become public – avoid sharing private and personal information (e.g., email address, home address or phone number for yourself or others).
- Review all rules and guidelines, and acknowledge that there are some risks involved in your participation.
- Take steps to protect your own safety during the participation of any UBC Physics Olympics activities.

We will not tolerate any of the following:

- Cheating or other forms of academic misconduct.
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- Messages that encourage or suggest illegal activity, contain sexually explicit material, contain advertising or promote any services, or are off-topic, unintelligible or irrelevant.

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2. General Rules

This year, UBC Physics Olympics will be held as an in-person competition. Some elements will be facilitated through online platforms, such as Canvas and possibly a virtual “buzzer” system. Teams may also participate in some events remotely as an exhibition only.

Each registered organization (hereafter simply “school”) enters students as a team. Up to five students from a team may participate in any given event. A school may request to have two teams, but each must have at least four students on the day of the competition. Two teams with fewer than four students on the competition day will be combined into one team. Events are designed so small team numbers are not penalized. Each event is run in six heats lasting about one hour each.

There is a break for lunch. Lunch itself is not provided, but the Student “Nest” building is across the street from the Hennings Building, which has many food options. You can find the location of the Nest here: https://planning.ubc.ca/sites/default/files/2019-11/UBCMap-Portrait.pdf

The event members of the top teams from each event will be awarded gold, silver, and bronze medals. Schools with the top six combined scores will receive plaques, and a travelling trophy will be awarded to the overall top school. Awards are only given for in-person participation. However, online participants will be recognized through the Physics Olympics website.

The combined score of a team is the sum of their decibel scores in the six events. For each event, schools are ranked by their event score, and the corresponding decibel score for that event is given by 10 log10 (rank) dB. Thus, a rank of first place 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 is the school with the lowest total decibel score. Online teams are not ranked. They may participate in Pre-build 1, Pre-build 2, and Fermi Questions only. Their participation will be acknowledged through Canvas and the UBC Physics Olympics website.

3. 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 and 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.

4. Use of Third-party Applications

The following applications may be used to support the Physics Olympics activities. This list will be updated as needed. If you have any concerns or questions about the collection of your information and the applications used during UBC Physics Olympics, please contact Kirsty Dickson, Communications Coordinator, UBC Physics & Astronomy at communications@phas.ubc.ca.

The following applications might not be hosted in Canada:

- Cosmic Buzzer (Links to an external site): Online buzzer system, which may be used in lieu of physical buzzers
- PhyPhox (Links to an external site): physical phone experiment application (Pre-build)
- YouTube (Links to an external site): video sharing and streaming platform (used within Canvas)

Some applications may ask participants to create an account in the tool; by doing so, you will be required to provide personally identifying information including but not limited to your name and email address. Because these tools might be hosted on servers outside of Canada, by creating an account you will also be consenting to the storage of your information outside of Canada. Please know you are not required to consent to sharing this personal information with the tool, if you are uncomfortable doing so. If you choose not to provide consent, you may create an account using a nickname and a non-identifying email address, or use tools that will provide disposable email addresses.

You may also choose not to participate in activities that require the use of these applications.

The following applications are hosted in Canada:

- Canvas (Links to an external site): online teaching and learning platform
- Kaltura (Links to an external site): online video hosting platform
- Qualtrics (Links to an external site.): online survey application and post-event survey

When using these applications, your personal information is collected under the authority of section 26(c) of the Freedom of Information and Protection of Privacy Act (FIPPA) (Links to an external site.)

Collected data will be used for the purpose of sending you information regarding the 2024 UBC Physics Olympics, and evaluating your participation in the UBC Physics Olympics competition.

5. Privacy and Recording

While the competition is not open to the general public and some safeguards will be in place to protect teams' privacy, teams should consider their usage of the Canvas platform, other applications, and their participation in Physics Olympics activities as being public, with the possibility of being recorded. Efforts should be made to avoid posting/sharing personal information including but not limited to text, video, and audio.

The Final Quizzics! event may be streamed within Canvas through YouTube. A video recording may be made by UBC Physics & Astronomy for internal use, which will be kept confidential and private.

6. Pre-Build Events

There are two pre-build events. For each event, teams are required to design and build devices in advance of the competition. At the start of the day, pre-built devices will be checked into a storage room until required for a heat. Modifications are not allowed after arrival. Exceptions are made at the discretion of the judges for the purpose of repairing damage sustained during transit.

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

We strongly encourage creativity, 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 general inquiries about the pre-build rules to Prof. Aaron Boley, preferably by email (acboley@phas.ubc.ca) or by telephone (604.822.3853), Monday-Friday 11 AM to 4 PM.

Pre-Build 1, Vacuum Pump

The rules are available at this link: https://phas-physoly.sites.olt.ubc.ca/files/2023/01/Vacuum-Pump-Rules-Final-1.pdf

Contact event judge Prof. Valery Milner at vmilner@phas.ubc.ca for questions.

Pre-Build 2, Marine Ambulance

The rules are available at this link: https://phas-physoly.sites.olt.ubc.ca/files/2023/02/Pre-build-2-Boat_AB_Fe b12023.pdf

Contact the event team at prebuild2@phas.ubc.ca for questions.

7. Labs

Heats (except the last) will be closed to all persons except the heat participants. Coaches will be allowed to view heats upon request. No more than five participants per team will be allowed in the lab. Teams are encouraged to bring a calculator.

The labs this year are: Centre of Mass Lab: The lab will explore the concept of the centre of mass and how mass distributions affect its location.

Air Resistance Lab: The lab will explore concepts of aerodynamic drag.

8. 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 for looking up information will result in disqualification. However, one device per team will be necessary for submitted responses.

All teams will participate in the preliminary Quizzics! heats. Questions are in a multiple-choice format. 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 approximately the first third of the questions, the correct answer is worth 1 point, while each incorrect answer (or failing to give an answer within 5 seconds) loses 1 point. For the next third, a correct answer is worth 2 points, and an incorrect -2 points. For the final third, a correct answer is worth 3 points, and an incorrect answer is -3 points. The winner is the team with the maximum number of Final Quizzics! points. Teams cannot go below zero points.

9. 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 (Links to an external site).

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, books, or calculators are allowed. Cellphones, tablets or computers are only allowed to access the Canvas site.

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.

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 Universal Gravitation
- the acceleration of gravity on Earth
- the radius of the Earth, and
- the distance from Earth to the Sun

Pre-build “Vacuum pump”

1. Objective.

Your objective is to build a device, hereafter referred to as the “vacuum pump”, capable of removing air from, and thus lowering the air pressure in, a test container provided by the judges. By design, the container will have a small leak – a hole with a diameter of about 1 mm.

Your vacuum pump is expected to produce a continuous pumping action, which will achieve and maintain as low a pressure as possible in the leaky container (see Test Procedure and Scoring section below for more information).

2. Device.

The vacuum pump has to be built so as to include the following features and to satisfy the following constraints.

A. General construction.

a) The pumping action, i.e. lowering the air pressure in the test container, must be accomplished solely via removing air from the container through a single pumping channel. No material should enter the test container during the pumping process.

b) The pump must feature a single flexible plastic tube, which will be connected to the output port of the test container, and through which the air will be pumped out of that container. The tube must be about 6” (15 cm) long and have an inner diameter of 0.25” (6.3 mm), so as to slide onto a standard barb connector pictured in Figure 1 below.

c) The pump must have a single activation switch, such as an electrical switch or a mechanical release lever, which triggers the pumping mechanism.

d) The device must not include a pre-pumped, i.e. a low-pressure, chamber.

e) The device must not include a commercially available air pump as one of its parts (e.g. an aquarium pump).

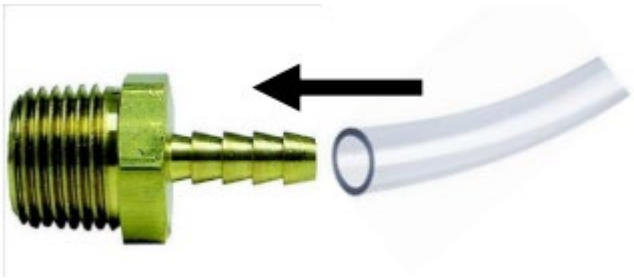

Figure 1. Brass barb connector for attaching a plastic PVC tube with 0.25” inner diameter. https://www.homedepot.ca/product/sioux-chief-1-4-inch-barb-adapter□brass-x-1-4-inch-fip-lead-free/1001002211

B. Size.

Except for the connection tube (see above), the whole pump must not exceed 50 cm in width, depth, and height. This size limitation must be maintained throughout the whole time of operation, i.e. all

moving parts must be contained within this volume. If anything is ejected from the main body of the pump during its operation (other than air!), the ejected parts must also be contained within the initial apparatus volume.

C. Weight.

There are no weight limitations. However, in the event of a tie, the lightest pump will win.

D. Energy sources.

The pump can be powered by any number and combination of only the following sources of energy.

a) Gravitational: hanging, falling or swinging weights are allowed as long as the constraints on the overall size and weight, described in sections 2.B and 2.C, are satisfied.

b) Elastic: any combination of elastic bands, springs and bent/twisted objects is allowed.

c) Electrical: any combination of not more than two standard 9V batteries from either Duracell or Energizer (Figure 2) is allowed. No other makes or types will be allowed, even if rated for 9 volts.

d) Gyroscopic: powering the pump by a spinning gyro is allowed as long as the gyro is spun either by hand or by the electrical power described above in Section 2.D.c). No external electrical devices (e.g. a power drill) will be allowed for spinning a gyro.

No other types of energy sources are allowed (e.g. no chemical reactions, thermal sources such as hot or cold bodies, compressed gases or liquids).

Figure 2. Allowed 9 volt batteries: standard Duracell or Energizer only. Not more than two batteries per vacuum pump is allowed.

3. Test setup.

The performance of your pre-built vacuum pump will be tested by means of a setup schematically shown in Figure 3.

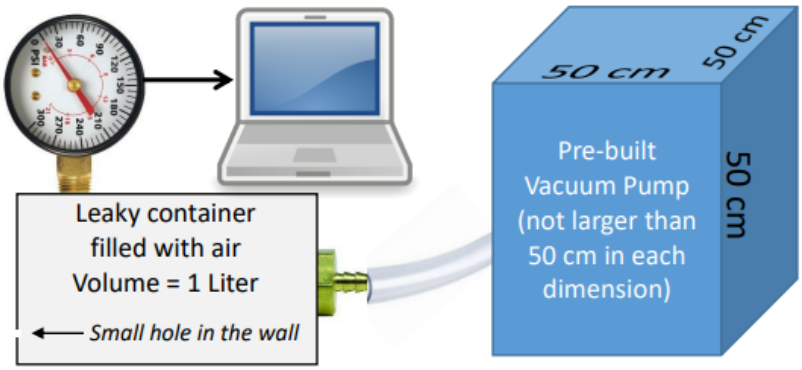

Figure 3. Scheme of a setup for testing the performance of a pre-built vacuum pump.

A. Test container.

The test setup consists of a 1 Liter container. The container is initially open to atmosphere and is therefore filled with ambient air at room temperature and atmospheric pressure. A hole with a diameter of about 1 mm is drilled in the wall of the container to produce a small leak.

B. Vacuum connection.

To test your pre-built device, it will be connected to the test container through a standard brass 0.25" barb connector shown in Figure 1. The part can be purchased at Home Depot (https://www.homedepot.ca/product/sioux-chief-1-4-inch-barb-adapter-brass-x-1-4-inch□fip-lead-free/1001002211). The team is responsible for making sure that a flexible plastic tube on their device will make an air tight connection with a brass barb.

C. Measuring device.

The test container will be equipped with an electronic pressure gauge connected to a computer.

4. Test procedure and scoring.

A. Connecting the pump.

Upon bringing your pre-built vacuum pump to the stage, your team will connect the pump to the test setup using the flexible plastic tube (See Section 2.A.b). No additional bands or clamps will be allowed to tighten the seal. The onus is on the team to make sure that a press fit of a plastic tube on the barb connector provides sufficient sealing.

B. Arming the pump.

Arming the pump, e.g. by stretching a spring or adjusting an internal weight, should be done in front of the judge and take no longer than one minute.

C. Starting the pump.

When ready, the team will be asked to start the pump (ready/set/go) using a single switch or a single mechanical action on their device.

D. Recording the pressure.

As soon as the team starts their pump, the judges will begin recording the air pressure inside the test container by means of a pressure gauge interfaced with a computer. The recording will continue for 60 seconds, generating a plot of Pressure-vs-Time, P(t), shown in two examples in Figure 4 below.

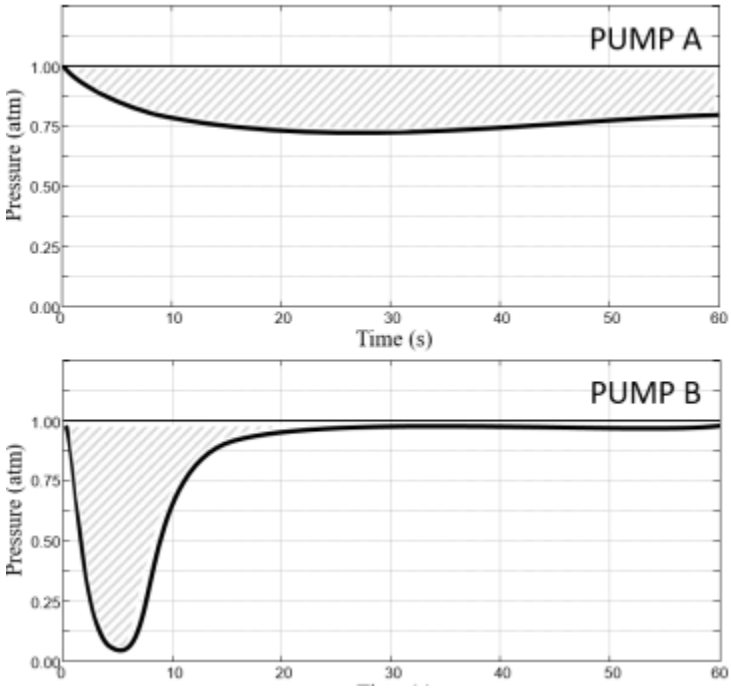

Figure 4. Examples of Pressure-vs-Time curves recorded with a pre-built pump.

E. Scoring the performance.

To assess the performance of your pump, the judges will calculate the area between the P(t) curve and a P=1 atm baseline, as shown by dashed surfaces in Figure 4. The bigger the area, the higher the score.

NOTE: Your vacuum pump is expected to produce a continuous pumping action lowering the pressure in the test container and maintaining that pressure for as long as possible despite the existing leak. For instance, in the examples above, Pump A scores better than Pump B, because of the larger area above the corresponding P(t) curve, even though Pump B produces much lower intermittent pressure in the test container.

Pre-build 2. Marine Ambulance

Your task is to design and build a model of a marine ambulance. The ambulance needs to be a boat that is fast, but gentle, with minimal acceleration in any direction. The boat must carry a cell phone that uses the free phyphox app (preloaded and remotely linked to an external computer) to record the boat's total acceleration during the race. The phone should be in a sealed Ziploc bag during the trials to avoid any damage to the phone should a marine accident occur. The boats will be tested two at a time in a container 244 cm long, 88 cm wide and 12 cm deep (Fig 1.). The width of the container will be divided into 2 test lanes. The start line will be 31 cm from one end of the container (See the start line in Fig 1 below, shown with grey tape).

Figure 1: Marine ambulance race container with two competition lanes.

During the race, the boat may not touch the bottom. The boat may bounce off the sides of its race lane, but any such contact must be momentary. The boat may not be in continuous contact with a side of the track or any on-shore object. The hull of the boat must be built from cardboard and saran wrap or aluminum foil. Tape and/or glue can be used to connect parts together but not to waterproof the hull. A paddle wheel or a propeller that is powered only by elastic bands or cords must be used for propulsion.

The shaft, propellers and paddle wheels may be pre-manufactured. Pre-manufactured gearboxes may also be used, if needed. Small metal pieces may be used for the purpose of mounting shafts, but such pieces may not be used to reinforce the hull. The size of the boat may not exceed 15 cm in width, 30 cm in length and 8 cm in draft (i.e., the distance from the waterline to the bottom of the boat). These dimensions include all parts of the boat. The boat should be started by cutting a thread immediately after the recording of the acceleration on the phone begins. The thread must be internal to the boat; cutting the thread starts the propulsion. The recording may be started remotely (from a computer) or manually. The judges must be able to see the smartphone at all times and verify that the data were recorded from just before to just after the race. The acceleration sampling must be every 10 ms (100 Hz sampling rate). After the boat touches the finish line (which is the end of container) or permanently stops on the track the recording must be stopped and the acceleration data sheet must be emailed to the judges.

The smartphone pre-loaded with the free phyphox app will be the only measuring device used in this pre-build activity. The app will record absolute acceleration during the process of transporting the phone using the "Acceleration (without g)" function.

In summary, the boat must be placed in the container, with the front of the boat just at the start line. It may not be held in any way. The recording of the acceleration data must begin just before cutting the thread, which again will start the propulsion. The thread cannot be tied to anything outside the boat. The testing run is finished when the boat touches the end of container or stops for more than 30 s or moves slowly for more than 180 s. In the last 2 cases the score will be multiplied by a factor of 1000.

Scoring: The score will be the sum of all recorded acceleration values during the race time to the third power. Acceleration values will be measured in m/s2 . The boat that produces the smallest score will win. Boats that do not finish the race (i.e., stop before the finish line or do not finish in 3 minutes) will have their score multiplied by 1000. There will be only one trial for each boat. Data submission format: Each team must submit one Excel file named according to the following template 'SCHOOL_NAME date and time.xls' (e.g., 'Lord_Byng 20-02-24 17-30-28.xls '). The file should be generated within the phyphox app by pressing on the menu sign and choosing "Export Data" and

then "Excel" format. The data file must not be modified in any way other than adding the name of the school in front of the date and time generated by the program.