

**THE TWENTY NINTH
UBC PHYSICS OLYMPICS
RULE BOOK**

March 10, 2007

Financial sponsorship is provided by the Rex Boughton Memorial Fund.

The UBC Physics Olympics is organized by the Department of Curriculum Studies (Mathematics and Science Education) and the Department of Physics and Astronomy.

In the Spirit of Physics

The wording of each challenge in this year's rule book has been carefully prepared to define each task as precisely as possible. It is expected that all participants will produce solutions which comply with the task as defined. Normal physical interpretations will be applied to all the terminology used in defining the tasks. Those solutions which, in the opinion of the judges, do not comply with the spirit and intent of the challenge, will be disqualified. General questions regarding the challenges may be directed to the coordinators of the Olympics. The coordinators will accept inquiries which may help them to prepare for unusually good solutions to the problem.

**Please direct all inquiries regarding the rules to K. Schleich or D. Witt at
preferably via email to schleich@noether.physics.ubc.ca or by phone to (604) 822-6286.
This rule book and any clarifications will also be available on the world wide web at
<http://noether.physics.ubc.ca/>.**

General Rules

Each school may enter one official team made up of a maximum of 10 members, of which a maximum of 5 participate in each event. Gold, silver and bronze medals will be awarded to the official teams scoring the highest, second highest and third highest aggregate scores. In addition, gold, silver and bronze medals will be awarded to the official teams scoring the highest, second highest and third highest aggregate scores. All teams must enter all events. The events are scheduled so that it is possible for all teams to enter all events. All ties will be broken. A trophy will be awarded to the school sponsoring the official team achieving the highest aggregate score.

TWO of the events require a pre-built structure. These entries must be checked in at the time of registration on the morning of the competition at which time they will be stored in a safe place until the time of the event.

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Hydromatic Lifter

BC Hydro is looking for new efficient designs to extract energy from resources that produce no greenhouse gases. The lifter should be able to do the most work possible (lifting a mass) using only the potential energy released by 2 litres of water falling in a waterfall of a maximum height of .75 meter. The lifter should be infinitely reusable without maintenance.

Apparatus:

1. The apparatus for this event consists of three parts, all supplied by the contestants: the waterfall the lifter and the mass.
2. The waterfall consists of a source (where all water is put at the beginning of the trial) a catch-basin (where all water is collected after a trial and a run (where the water flows during the trial). Note that the run need not be physical; water can be allowed to freely fall between the source and the catch-basin).
3. The top of the water level in the source at the start of the trial must be no more than .75 meter above the lowest point of the catch-basin.
4. The waterfall must be designed to catch all of the water in the catch-basin. It must also be designed so that all of the water collected in the catch-basin can be easily poured by the contestants into a bucket.
5. The lifter must be separate and independent of the waterfall. In particular it can hold no water either at the beginning or end of the trial; i.e. it cannot be part of either the source or the catch-basin.
6. The mass must be specified to the judges to contestants at the beginning of the trial. The mass must be a single solid and rigid object of dimensions less than 20 by 20 by 20 cm. It must be connected to the lifter by thin string, wire, fishing line or other essentially massless material.
7. The apparatus must be designed so that at the end of the trial, the mass is held into its final elevated position for measurement by the judges.
8. The entire apparatus (all three parts) must fit in a 1 by 1 by 1 m box at all times.
9. The apparatus must be constructed entirely by the contestants themselves and should not consist mainly or exclusively of any sort of pre-purchased device.

Rules:

1. Teams will have a total of 5 minutes to set up and run a trial. Only one trial will be allowed.
2. At the beginning of the trial, organizers will provide contestants with a 2 liter pop bottle filled with UBC tap water. The only source of energy for lifting the mass must be provided by the potential energy of the supplied water falling a maximum distance of .75 meter.
3. During set up, contestants can place the provided water in the source as desired. At the start of a trial, the team will start the flow of water when directed to by the event organizers. The trial will end when either all water has flowed from the source to the catch-basin or 3 minutes after the start of the trial.

4. No external human intervention is allowed after the start of the trial.
5. The final configuration of the apparatus must be the same as that of the initial configuration except for water having moved from source to catch-basin and elevation of the mass. In particular, no part of the apparatus is allowed to transfer stored energy to lift the mass.
6. The winning team will do the most work done on the mass using the energy released by the falling water. This work will be computed from using height as measured by the vertical displacement from the lowest point of the mass before the trial to the lowest point after the trial.

The Electrical Maze

This event will require teams to race to solve an electrical maze.

Materials: The following equipment will be provided:

multimeters
paper
ruler

Rules:

1. Contestants are not allowed to bring or use any materials or equipment other than those provided with the exception of calculators and pens or pencils for writing.
2. Teams will be given a DC power supply and a small subcircuit containing one or more light emitting diodes and a circuit with some or all of the following components: resistors, capacitors, switches and diodes. The components may not necessarily be visually identifiable to the contestants; it may be necessary to identify them using their properties and the provided equipment. Recall that a diode is a component which allows the passage of current in only one direction. A capacitor is a charge storage device with the property that it does not allow the passage of DC current. A switch is a device that allows current to pass in both directions when closed, and does not allow current to pass when open. A resistor have a relationship between V and I that follows Ohm's law.
3. Each team will be expected to find a path through the circuit that will provide a specified voltage and current to the small subcircuit. Successful completion of this task will cause the light emitting diode or diodes to perform in some specified manner. This path will be made by opening and closing switches. Each team will also be expected to draw a circuit diagram of the entire maze and provide other required information about the circuit. These diagrams will be turned in when the team has successfully solved the maze and will be used in the scoring.
4. Each team will be awarded a time based on the time that their circuit diagram is turned in to the event organizers. The winners of the event will be determined by the least time taken in finding a correct solution.

Mystery Event

This event will involve solving a simple experimentally oriented problem or problems using logic and knowledge of basic principles of physics.

Intuitive Physics

Each team will be presented with simple experiments or simulations based on basic principles of mechanics, electricity and/or magnetism. Teams will be required to provide answers to questions based on these experiments or simulations. Answers to questions may involve simple calculations. The team with the most correct answers will win. Quality of answers involving explanations will be used to resolve ties.

Optical Target Practice

The goal of this event is to direct light beam through optical elements to hit a target. The optical obstacle course will contain optical objects such as lenses, prisms, plane mirrors and other transparent objects with specified indexes of refraction. Some course elements will be fixed and some will be movable.

To prepare for this event, contestants should be able to use Snell's law, and the law of reflection, the lensmakers equation ($1/s + 1/s' = 1/f$) and understand magnification. Contestants should bring a non-programmable calculator, pencil, protractor, and a ruler.

Rules:

1. Students may not move any of the fixed course components. One fixed course component will be the light source. Other components that are fixed will be specified at the time of the event.
2. The beam may be required to pass through certain fixed course components for a successful completion of the event. These components will be specified at the time of the event.
3. A maximum of fifteen minutes will be allowed for each team to set up the movable objects in the course. No movable course objects may be placed outside of the designated course boundaries. Only the equipment provided may be used.
4. No trial runs are permitted. The light source will be turned on by one of the event coordinators after the students' set-up is complete. (Alternately, at the end of the allotted time if this comes before the contestants have fully completed their set-up).
5. Score will be based on accuracy at hitting the target in the specified manner with severe penalties if beam path misses the required fixed course components. Time spent in solving the course will be used to resolve any ties with shorter time being better.

Rescue Submarine

A submarine has been lost at sea. Time is of the essence. Deploy a rescue submarine to dive, pick-up survivors, and bring them to the surface. Your submarine must bring as much payload as possible off the sea floor and float it to the surface.

The Test Basin

1. The submarines will be tested in a sea of depth 40 cm.
2. The sea has a diameter of at least 25 cm and it will be filled with room temperature UBC tap water. The sea is surrounded by nonmetallic and nonmagnetic land (the container).

3. The survivors consist of 200 g of 2 1/4 inch bright common nails (type 7d) located in a circular area of roughly diameter 15 cm.

The Apparatus

1. The apparatus consists of two parts: the submarine and the ballast. The apparatus must be entirely self contained, with no external connections or power source. The submarine will retrieve and return passengers to the surface. The ballast can be left on the bottom. The apparatus design must have a submarine but is not required to have ballast. Contestants must specify these parts to event organizers before the trial.
2. If used, ballast must consist of no more than 2 solid pieces of insoluble material or water. If using water, the design must use tap water provided by event organizers. The mass of this water will be counted as ballast.
3. The submarine must fit into a sphere of 15 cm diameter at all times during the trial. Ballast must fit into the submarine until it is within a distance of 10 cm from the sea bottom. When ballast is dropped it must completely separate instantaneously.
4. This is an environmentally friendly submarine. The operation of the apparatus must not contaminate or evaporate the sea or damage the land (the container) or survivors. In particular, there shall be no dissolving or decomposing parts to the submarine or ballast.
5. Any dropped ballast must be easily recoverable.
6. The device must be constructed entirely by the contestants themselves and should not consist mainly or exclusively of any sort of pre-purchased device.

Testing

1. Teams will have 5 minutes to deploy and test their submarines. Repeat, time is of the essence.
2. At the start of a trial, the team will begin the dive when directed to by the event organizers. No external human intervention is allowed after the start of the trial. Only one trial is allowed.
3. The apparatus must freely dive to the bottom of the sea, retrieve as many survivors as possible, and return to the surface, all without touching land at any time (i.e. the sides of the container). Touching the sea floor (ie. the bottom of the container) during the operation is allowed.
4. At the end of the trial, the submarine must breach the surface and remain on the surface with some part of its structure above the surface for 30 seconds in order to score. The survivors brought up in or on the submarine present after this time will be part of the score.

Scoring

The winning submarine will recover the most survivors using the least mass of ballast. In the unlikely event of a tie, the submarine that is quickest at rescuing the survivors will win.

Good luck, and Godspeed.