# THE NINETEENTH

# UBC PHYSICS OLYMPICS

# RULE BOOK

# March 9, 1996



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First Annual Physics Olympics Open Event


Financial sponsorship is provided by the Rex Boughton Memorial Fund.


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

***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 822-6286 or via email to olympics@noether.physics.ubc.ca. This rulebook will also be available on the world wide web; email olympics@noether.physics.ubc.ca for more information.**

***General Rules***

Each school may enter one official team made up of a maximum of five members. If space permits, each school may enter one additional, unofficial team in all events. Gold, silver and bronze medals will be awarded to the official teams scoring the highest, second highest and third highest aggregate scores. Both official and unofficial teams are eligible for these medals. In addition, gold, silver and bronze medals will be awarded to the official teams scoring the highest, second highest and third highest aggregate scores. The official teams must be designated at registration. 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. Points scored by unofficial teams will not be included in the school championship aggregate.

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.

***Our Special Thanks to the Event Designers:***

Irfan Dhalla, Paul Harrison, Steve Brown, Irene Vavasour
Jenny Riecken, Elizabeth Nethery, Bethany Jackson, Paul Paddon,
Hurbert Pun, Don Witt, Ron Horwood

and to

Dr. Brian Turrell, Head UBC Department of Physics

and all students of the Physics and Physics Engineering program who assist in the organization and running of this Physics Olympics.

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## Electric Produce

This pre-built event involves the design of a battery that utilises chemicals found in produce and other edible items found in your kitchen at home. **The object is to build a battery which does the most work.** A simple example of a battery is given below.This battery will give you a score but to attain the best score you will need to try different designs.

**Apparatus:** The entire apparatus will be called the battery. The battery consists of a container which holds the basic components. The basic components are the electrodes, the electrolytes and the terminals. Each team must bring the entire battery.

1. The battery must be constructed entirely by the contestants themselves. The battery must fit into a box of 30cm by 30 cm by 30 cm. Oversized batteries will be disqualified.

2. The electrolyte must be made **only** from food items. More precisely, any electrolytes used in the battery must be safe to eat. Teams should be prepared to demonstrate the nature of their electrolytes by consuming samples of them from their battery in the presence of the judges if requested. The electrolytes may only be prepared for use by mechanical food preparation techniques: slicing, dicing, juicing, grinding, stirring, etc.

3. The electrodes can be made from materials containing only aluminium, copper, nickel, iron, tin, steel, zinc or carbon.

4. Other substances may be used in constructing the battery provided they are not electrolytes or electrodes and are non-toxic in the presence of the electrolytes. Examples of such substances are plastic food containers, coffee filter papers, cardboard, natural colored cloth, Styrofoam and resistors.

5. A cell refers to a single container with one electrolyte and two electrodes. A battery may consist of multiple cells attached via terminals. The terminals can be made out of wire or any other conductor.

6. A battery consisting of multiple cells should be contained in single container with two terminals, identified to the organisers as the positive and negative terminal. These terminals should be constructed such that small alligator clips can be easily and securely attached to them for measurements.

7. Teams must supply a written description of their battery clearly indicating all electrolytes used, all electrodes used, and all other substances used in its construction. Teams must also specify the initial voltage and current of their battery.

**Rules:**

8. At the start of the event, teams will be given 5 minutes to set up their battery. During this time, it is permissible to perform final assembly tasks on the battery, such as adding electrolytes to the cell or cells if desired.

9. After set up, the internal resistance $r$ will be measured by the judges. After this initial measurement, the voltage $V$ across a load will be measured at equal time intervals for 10 minutes. This load will consist of a resistance equal to the initial measured internal resistance $r$ of your battery. The length of the time interval will be set by the judges on event day and be the same for all teams. Once the testing begins, no team can touch their battery.

10. After testing, the size of the battery will be measured. This measurement will be based on volume. This volume will be that of the smallest cubic box that the battery will fit in completely. There will be three box sizes provided for this test: 10 cm by 10 cm by 10 cm, 20 cm by 20 cm by 20 cm, and 30 cm by 30 cm by 30 cm.

11. Upon request, teams will be required to disassemble their battery after testing to verify its compliance with the rules.

12. The score will be given by the work done by the battery on the load over the ten minute period divided by the volume of the smallest box that it fits in. The work will be computed from the power at the specified time intervals,

$$P = V^2 / r$$

where *r* is the resistance of the load in ohms and *V* is the voltage in volts across the load as measured by the judges at the specified time intervals. Oversized batteries will be disqualified.The winning battery will be that with the largest score.

**Example:** The following is an example of a single cell battery. Place juice from half of a lemon in a small glass dish, add table salt and stir. Next, place a penny in one side of the dish so that it is partially exposed to the air, and aluminium foil in the other side of the dish again partly exposing it to the air but not touching the penny. Next, measure the voltage and current using a multimeter by touching exposed parts of the penny and foil. In this example the electrolyte is the salted lemon juice and the penny and foil are the electrodes. This battery is not the best possible battery as it has relatively high internal resistance.However, it will get a score. Note that to get the best score, you want to make the internal resistance of your battery low.

## Intuitive Physics

Each team will be presented with three to four simple demonstrations or experiments based on basic principles of mechanics, electricity and magnetism. Teams will be required to provide answers to questions based on these demonstrations or experiments. 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.

An example of a simple demonstration is the following:

Teams are provided with plastic rods, one of which is suspended on a string, fur, silk and other items. Teams are invited to see what happens when the rods are rubbed with the various items and placed near each other. Teams are then asked which items have like charge and which have opposite charge when rubbed against plastic rods. Teams are also asked to explain how they arrived at their conclusions.

## Archimedes Principle

Teams will be required to determine the densities of various unknown fluids using Archimedes principle.

**Rules:**

1. Teams will be allowed to bring and use non-programmable calculators, pens or pencils and paper for the sole purpose of computing and recording results.

2. The materials provided by the event organisers will come in different sets. A list of contents of each materials set will be provided to each team at the beginning of the event. Each set will cost a specified number of points, with sets that are easiest to use and produce the most accurate results costing more points then sets that require more ingenuity and/or produce less accurate results. Teams must then decide which set to use to perform the required density measurements and request this set from the event organisers.

3. Teams are allowed a total time of 30 minutes to complete this event. At the end of this event, teams must clean up their work area and return all components of their materials set to the event organisers or else be disqualified.

4. The team's score will be based on the accuracy of the densities determined for the various unknown fluids multiplied by the cost of the set used in making the measurements. At the time of the event there will be a short series of bonus questions that will be used to resolve ties.

## Mystery Event

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

## Optical Obstacle Course

The goal of this event is to direct a laser beam or beams through an optical obstacle course to a hit a target as accurately as possible. The optical obstacle course will contain optical objects such as 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. 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 laser. Other components that are fixed will be specified at the time of the event.

2. The beam or beams may be required to pass through certain fixed course components for a successful completion of the obstacle obstacle course. 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 laser will 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 ). After the laser has been turned on by the coordinator, no course objects may be moved.

5. Score will be based on accuracy at hitting the target 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.

## The Rubber Band Powered Cable Car

This is a pre-built event which involves the design of a car that utilises the energy stored in two rubber bands to move a distance of **precisely 3 meters up an inclined cable and then to return to the starting line in the fastest time.**

**Apparatus:** The part of the apparatus that will be measured for distance is called the car. The entire apparatus can be the car itself. The car must be designated by the contestants before the beginning of the trek up the cable to the mountain.

1. The total energy for moving the car can **only** come from the elastic potential energy stored in at most two Apsco brand Size 31 radial rubber bands 60mm x 3.0mm x 1.1mm. The two rubber bands will be supplied by the event organisers. They can be utilised in any way and do not have to remain in original condition. They do not need to be returned to event organisers.

2. The apparatus must be constructed by the contestants themselves and should not consist mainly or exclusively of any sort of pre-purchased model kit or device. The car's mass must be less than or equal to 2 kg.

3. The car must be designed to carry a passenger consisting of one adult *Playmobil* figurine. (See figure 1.) The figurine will be provided by event organisers on race day and must be returned undamaged at end of test runs. Thus, for example, it can be belted into the car but cannot be glued or stapled to the car on race day. The adult figurine weighs approximately 13 gm and is approximately 7.5 cm tall by 3.5 cm wide by 2 cm deep while standing and 5 cm tall by 4 cm deep while sitting. Note that both the arms and legs of the figurines are positionable.

**Figure 1: Playmobil adult and child figurines.**

4. The car must be able to trigger timing gates positioned at the starting line and near the summit point; that is it must contain some opaque part that is at least 5 cm in width at any height between 8 and 13 cm below the position of the cable **before** the car is attached. Note that you should compensate for any sagging in the cable caused by your car in positioning this part. This opaque part must also be parallel to the length of the car.

**Racecourse:**

5.The car is required to move on a 40lb test monofilament fishing line called the cable. One end of the cable is attached to the face of the mountain. A 4 kg mass attached to the other end hangs a vertically suspended from a support tower of height 0.7 meters as shown. The cable will be at 15 degree angle relative to a plane parallel

to the floor before the car is attached. The total linear length of the cable is 6 meters between the face of the mountain and the support tower.

6. The starting line and summit point are 3 meters apart as measured along the cable with no car attached.There will be a cardboard barrier placed around the cable at a point approximately 1 meter behind the starting line. There will also be a cardboard barrier placed around the cable approximately at the face of the mountain.The start box is the volume between this barrier and the starting line, below the cable and .5 meter to each side of the cable.

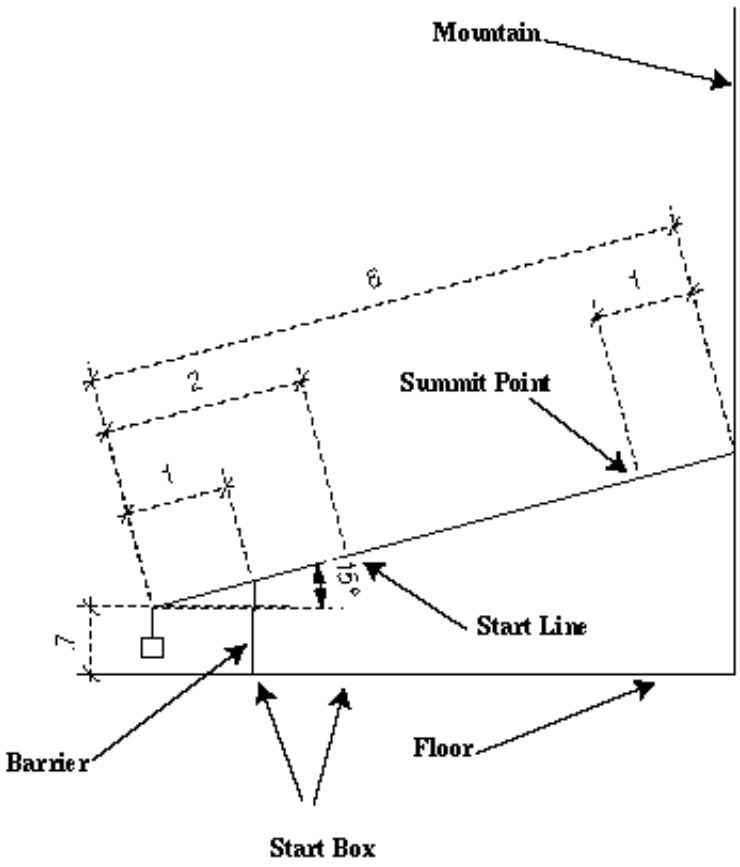



**Figure2: Side view of racecourse**

**Rules:**

7. Teams will have a maximum of 8 minutes to set up their apparatus and complete two trial runs. Teams can make adjustments on their apparatus between trial runs.

8. The car must be attached to the cable by some means such as a hook or eyelet that does not require dismantling the racecourse. The car is the only piece of the apparatus that may touch the cable at any time during setup and the two trial runs. The car must remain attached to the cable at all times during its trial run.

9. No part of either the apparatus or the car can be outside of the start box or in front of the starting line before the release of the car. Only the car can be in front of the starting line during the trial run. The car must be released from rest. No external intervention is allowed after the release of the car. **Specifically, no external intervention is allowed to stop the car or restart the car for its return trip to the starting line.**

10. The car must transport the Playmobil figurine to the summit and back across the starting line.

11. If the cable breaks during the run, your team will be disqualified if the judge deems the break to be caused by your car.

12. The maximum score will be attained by a car that travels a distance of precisely 3 meters and returns from this point back to the starting line in the fastest time. **The distance will be the shortest distance from the rear most point of the car to the starting line measured along the cable.** Note that, for example, if a string attaches the car to the apparatus in the start box, the distance travelled is zero.

13. The score for a trial run is given by the formula T|d-3| +T for 2.8 <= d <= 3.2 where T is your time of the return trip from the summit point to the starting line and d is the distance in meters. The score is given by the formula 10|d-3| + 10 for d < 2.8 and 20|d-3| + 10 for 3.2< d< 4. If any part of your car hits the cardboard barrier in front of the face of the mountain or any other object before crossing the starting line on the return trip, the score is given by the formula is 50|d-3| +10.

14. The lowest score attained in the two trial runs will be used as the team score. In the event of a tie, the lowest sum of both scores will be used to resolve the tie.

# The First Annual Physics Olympics Open Event

This year, we are pleased to announce a completely optional event designed for the participation of those people who accompany the official teams to the Physics Olympics. This event **is not** an official Physics Olympics event and is intended for any teacher teams, informal B teams (those not participating in the regular Physics Olympics events) and any other informal teams who wish to try it. No trophies will be awarded in this event, but the names of the top finishers will be announced at the awards ceremony. This event will be run at announced periods all day; anyone who wishes to participate can do so by showing up at one of these times. This year, we will revisit the 1992 classic event,

## Paper Boat Race

The object of this event is to build a paper sailboat that will sail the racecourse described below in the fastest possible time carrying an apple.

**Materials:** The contestants will be required to bring the following two supplies:

1. A stapler with staples.
2. Scissors.

The event organisers will provide each team with exactly three 8.5 x 11in. sheets of paper. Also, everyone will be provided with access to a small testing tank with water to balance their boat before the race.

**Rules for construction of boat**:

1. The boat must be constructed from no more than three 8.5 by 11 sheets of paper and staples. This paper will be 20 lb. long grain white copy paper of type typically used in copiers and will be provided by event organisers. An unlimited number of staples are allowed. The paper may be cut into any shape and as many pieces as desired. Contestants may bring a "blueprint" of their boat design to aid in the construction, but no piece of the blueprint may be incorporated into the boat itself.

2. The boat must not be longer than 9 inches and must have a sail that reaches a minimum height of 4 inches above the water line. The profile of the sail must be at least 1 inch wide at the height of 4 inches to ensure triggering of the timer.

3. The boat must be designed so that it will carry one medium size apple. This apple will be supplied by the event organisers and must be returned in good condition at the end of the race.

**Racecourse:** The course will consist of an 8 foot long by 3 foot wide by 5 inch deep trough filled with water. The starting gate will be placed 9 inches from one end of the trough and the finish gate will be placed 9 inches from the other end of the trough. There will be a source of wind power provided; it will be produced by a standard 22 inch by 22 inch box fan on low setting. The fan will be placed 3 to 4 feet away from the starting end of the trough.

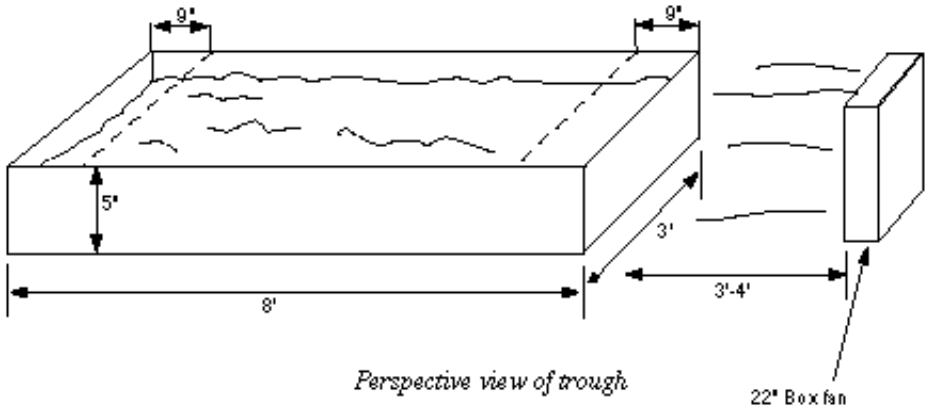
**Rules:** For racing and scoring:

4. The back end of the boat will be placed against the end of the trough nearest to the starting gate and released by a member of the school team.

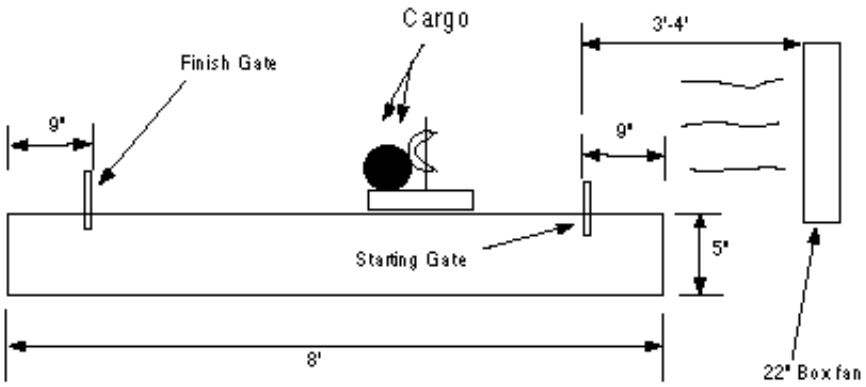
5. The timer will start when the sail crosses the starting gate and stop when the sail crosses the finish gate.

6. The boats are allowed to hit the sides of the trough and will not be disqualified if they take on water, assuming that they finish.

7. The winning boat will be the one with the fastest time. Should there be a tie for best score, another set of time trials will be run to break the tie. The judge's decisions will be final.



*Perspective view of trough*




*Side view of trough*