# THE TWENTIETH

# UBC PHYSICS OLYMPICS

# RULE BOOK

# March 8, 1997



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Second 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 rule book 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 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, Jenny Riecken, Bethany Jackson, David Gipson, Benny Fok, Kathy Lee, Richard Mar, Anson Li, David Du, Karen Lee, Lucy Ling, Joze Reverente, Iris Teo, Lilian Fan, Arman Rahmim, Timothy Edmunds, Adrien Desjardins, Jennifer Whitman, Warren Code, Kevin Lam, Flora Graham, Graham Bustard, Vince Beyer, Kathy Bright, Chris Habdank, Pieter Blue, Sherri Yurkowski, Gordan Samoukovic, Catherine Murray, Don Witt

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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# The Lilliputian Catapult

This is a pre-built event which requires the design of an apparatus that utilises the energy stored in one rubber band to launch a package at a target whose centre is precisely 2 meters away**.**

**Apparatus:** The part of the apparatus that will be measured for distance is called the package. The part of the apparatus that launches the package is called the catapult. The apparatus may consist entirely of the package itself. The package must be designated by the contestants before the beginning of the event.

1. The total energy for launching the package can **only** come from the elastic potential energy stored in one Apsco brand Size 31 radial rubber band 60mm x 3.0mm x 1.1mm. The rubber band will be supplied by the event organisers. It can be utilised in any way and does not have to remain in original condition. It does 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.

3. The apparatus must have an initial height less than 20 cm above the floor. The catapult must have a maximum height of 20 cm above the floor at all stages of the launching procedure. The catapult must have a maximum width and length less than 50 cm.

**The Theatre:**

4. The theatre is illustrated in Figure 1 below. It consists of a 4 meter by 1 meter area of hard linoleum floor. The starting line is 1 meter from one end of the theatre. Behind the starting line is a 1 meter by 1 meter staging area for set-up and launching of the apparatus. In front of the starting line is a 3 meter by 1 meter siege area. A 30 cm high by 1 meter wide by 2.5 cm thick polystyrene wall parallel to the starting line is at a distance of 1 meter. The centre of a circular target is two meters from the starting line. Three meters from the starting line is the ending line.

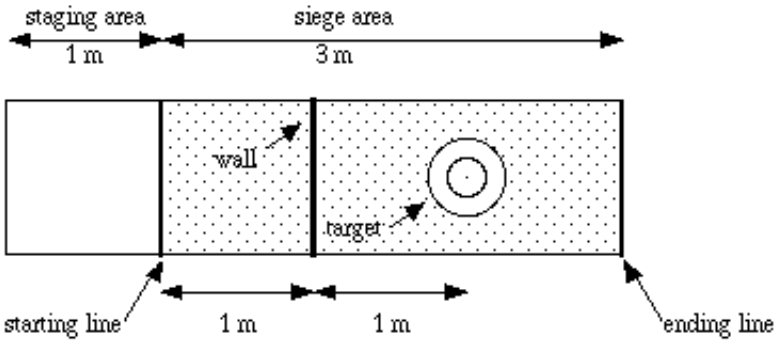


*Figure 1. Diagram of the theatre.*

5. The circular target is illustrated in Figure 2 below. Its overall diameter is 1/2 meter. It is made of construction paper and is secured to the floor by tape. Its top is marked with a set of concentric circles of diameter 5, 10, 15, 20, 25, 30, 35, 40, and 50 cm. Scoring will be based on which of the concentric circles the package lies entirely within after it comes to rest.

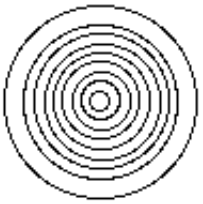

*Figure 2 Diagram of the circular target.*

**Rules:**

7. Teams will have a maximum of 8 minutes to set up their apparatus and complete four trial launches. Adjustments can be made on the apparatus between trial launches. Teams may either use the same package or identical packages for each trial launch. Teams must notify the judges in advance if they intend to use identical packages. Judges will determine at that time whether or not packages are sufficiently identical. Criteria are that the identical packages must be made of the same materials and have the same weight, shape and overall appearance.

8. The ceiling of the event area is at a height of approximately 4.2 meters from the floor. Packages that hit the ceiling at any point during their launch or damage the hard linoleum floor will be disqualified.

9. No part of either the catapult or the package can be outside of the staging area or in front of the starting line before the launch of the package. No part of the catapult may be in front of the starting line during or after the launch. No external intervention is allowed after the release of the package. **Specifically, no external intervention is allowed to stop the package.**

10. No external human intervention is allowed to align, aim or secure the catapult or package at any time during a launch. For example, a student cannot hold the catapult upright during the launch. Note that this rule does not exclude human intervention to release the catapult. For example, a student may use a finger to release a hook that fires the catapult. Also note that the catapult may be secured by nondestructive means such as tape to the floor in the staging area so long as any residue is carefully removed by the end of the 8 minute period.

11. The package must remain in or above the theatre, that is the 4 meter by 1 meter area, at all times for a trial launch to be successful. Packages that do not will be given a penalty score of 1000 cm for the trial launch.

12. The score for a successful trial launch will be determined by the distance from the centre of the target at which the package comes to rest. This distance is determined by which concentric circle on the target the package lies entirely within. Packages that break into pieces will be given a score based on the distance of the furthest piece from the centre of the target. Packages that miss the target but land between the wall and the ending line will be given a score based on the distance (measured in 5 cm increments) from the centre of the target they lie entirely within. Packages that land anywhere else in the theatre will be given a penalty score of 1000 cm.

13. The best three out of the four trial launches will be summed to find the final score for this event. The lowest score, corresponding to the most accurate targeting, will win. Ties will be broken by the weight of the package used; the team using a heavier package will place over the team using a lighter one.

# Flying Balloons

Teams will be required to determine properties of a specified gas or gases using Archimedes principle and Boyle's law (the ideal gas law).

**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. Teams will be provided with the following materials:
a meter stick
string
several paper clips
assorted washers
a balance
safety goggles
containers for gases such as balloons or paper bags
a magical sheet of information
several mystery items

3. Using the above items it *is* possible to determine a property or properties of the specified gas or gases. Don't panic; the magical sheet of information will be very helpful.

4. The team's score will be based on the method used and the accuracy of the properties determined for the specified gas or gases. In case you finish quickly, there may also be a short series of bonus questions which may increase your score.

# Making Waves

This event involves an experiment that studies the reflection and interference of sound waves.

**Rules:**

1. Teams should bring a non-programmable calculator, pencil or pen, protractor, and a ruler.
Teams are not allowed to bring or use any materials or equipment other than the above with the exception of the apparatus for the event.

2. The apparatus will consist of one or more sources that generate sound waves of constant frequency, one or more flat surfaces that reflect sound waves, and a pressure sensitive detector that measures the intensity of sound at a given location. Some of these elements will be at fixed locations and some will be movable. Which elements are fixed and which are movable will be specified at the time of the event.

3. Teams will have a maximum of 20 minutes to measure a property of this system by devising an experiment that will do so using the given apparatus. Such an experiment may consist of a series of repositionings of the movable elements in the apparatus.

4. Teams will be judged on the accuracy of the value of their measurement. Time spent in solving the course will be used to resolve any ties with shorter times resulting in a better placement.

# 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 several simple demonstrations, simulations or experiments based on basic principles of mechanics, electricity and magnetism. Teams will be required to provide answers to questions based on these demonstrations, simulations 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.

# The Edible Resistor

The object of this event is to build two resistors on site of edible materials that most closely match two different resistances specified by the judges on event day. These resistances will lie in the range of 1000 - 100,000 Ohms.

**Apparatus.** The entire apparatus will be called the resistor. The basic components of a resistor are edible or chewable materials providing the resistance, a container if desired, and two wire leads.

1. Contestants must bring all materials needed for construction of two resistors of resistance in the range of 1000 - 100,000 Ohms on event day. Contestants must also bring any tools needed for the construction of these resistors such as rulers, measuring cups and spoons, micrometers and wire cutters. Contestants may also bring notes to aid in their construction of these resistors.

2. Contestants must **not** bring a multimeter or any other device to measure resistance. **Teams found to possess such a device on the day of the event will be disqualified.**

3. The resistor must be constructed entirely by the contestants themselves. Excluding leads, it must fit into a box of 5 cm by 5 cm by 10 cm. Oversized resistors will be disqualified.

4. All resistive materials in the resistor must be safe to eat or chew. Examples of materials are kiwi skins, orange sections, salt, paper, and vinegar. Teams should be prepared to demonstrate the nature of their materials by consuming or chewing samples of them in the presence of the judges if requested.

5. The container if desired must consist of non-toxic materials of infinite resistance. Examples of such materials are glass and plastic containers.

6. Contestants must securely attach two wire leads each of approximate length 20 cm to each resistor. These leads should be constructed such that small alligator clips can be easily and securely attached to them for measurements.

**Rules:**

7. At the start of the event, two randomly selected resistances in the range of 1000 - 100,000 ohms will be chosen and told to the teams. Contestants will then have 10 minutes to build two different resistors that have these specified resistances out of the supplies brought by them to the event. Contestants must label each resistor with the appropriate target resistance.

8. After the end of the 10 minute period, each resistor will be measured to ensure that, excluding leads, it fits in a 5 cm by 5 cm by 10 cm box. Resistors that do not do so will be disqualified. The resistance of resistors meeting this size requirement will be accurately measured by the judges.

9. The score for each resistor will be given by

$$1000(Rm-Rs)/Rs$$

where Rm is the resistance measured by the judges and Rs is the resistance specified by the judges at the start of the event for this resistor as indicated by the contestants. The total score for the event will be the sum of the scores for each resistor. Disqualified resistors will be assessed a penalty score of 100,000 in the computation of the total score. The team with the lowest score will win. Any ties will be broken by the judge's assessment of creativity of design.

**Example:** The following is an example of a resistor. Take a 2 cm long piece of kiwi skin that has a little kiwi on it. Measure its resistance with a multimeter. Now sprinkle salt on it and observe that the resistance changes. Try out some other materials and see what different resistances you get. To get the best score in this event, you will want to devise a repeatable recipe for a resistance that you can implement on event day without a multimeter!

# The Second Annual Physics Olympics Open Event

This year, we are again 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 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 1995 event,

## Paper Bridge

The object of this event is to build a paper bridge on site of the smallest amount of material that supports the largest possible weight.

**Materials:**

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

1. Standard paper staplers with standard staples
   (Staples with 1/2" crown, 1/4" leg, chisel point.)
2. Scissors.

The event organisers will provide each team with exactly five 8.5 x 11 in. sheets of paper. Please note that you will only be allowed to use the paper that is given to you by the event organisers.

**Rules for Construction of Bridge:**

1) The bridge must be constructed from no more than five 8.5 by 11 in. sheets of paper and staples only. 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, but every staple used in the bridge must pierce some piece of paper provided by event organisers. The paper may be cut into any shape and as many pieces as desired. Contestants may bring a "blueprint" of their bridge design to aid in the construction, but no piece of the blueprint may be incorporated into the bridge itself.

2) The bridge must have a minimum clear span of 36 cm and an overall length of no more than 80 cm. It must be constructed in such a way that it can be supported at both ends on a flat horizontal surface. It must have a roadway, i.e. a 3 cm wide flat surface with a slope of no more than 10 degrees anywhere along it that touches both flat horizontal surfaces. (See Figure 1.)

3) Bridge must be strong enough to support the chosen weights for 1 minute.

**Rules for Event:**

4) A selection of standard Cenco weights of masses up to 1 kilogram will be provided by event organizers. Contestants will be able to select from these weights which and how many they wish to set on the deck of their bridge.

5) Contestants will be provided with two horizontal surfaces set a distance of 36 cm apart. Each surface will be covered with one 228 mm by 279 mm sheet of 80 grit garnet paper backed sandpaper secured with masking tape. The sandpaper will extend to the edge of the surface. The bridge must sit freely on these surfaces; it cannot be secured to these surfaces by staples or any other means. Moreover, the horizontal surfaces must provide the sole source of support for the bridge; for example, the bridge cannot be supported by the floor, ceiling or vertical edges of the surfaces.

6) Contestants will have 5 minutes to set up their bridge to traverse this required minimum span and demonstrate that it will hold the selected weights for one minute.

7) Contestants will notify event organisers when they are ready to begin. Event organisers will then indicate that they are ready to judge the event. Weights will then be placed on the bridge by the contestants. They must be on top of the roadway with no part hanging below the roadway and must be supported only by the paper bridge; that is they must not be supported in whole or in part by the horizontal surfaces or any other support.

8) Bridges that collapse in under one minute result in disqualification. The score for bridges that support the chosen weights for at least one minute is given by the following formula: $W/(P+2)$

where W is the total of the chosen weights and P is the number of sheets of paper used in whole or in part by the contestants. The bridge that maximises this score wins. In the event of a tie, the bridge with the fewest staples will place highest.

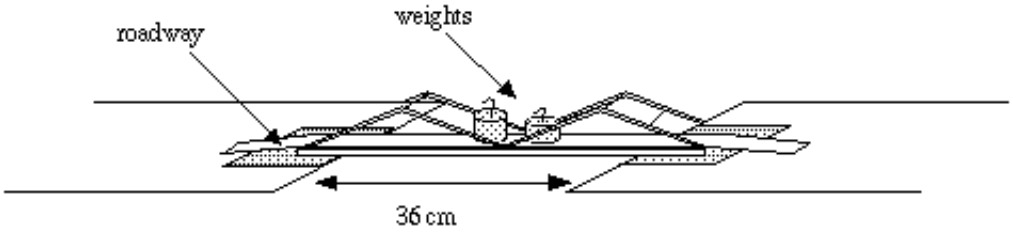


*Figure 1: Example of a Bridge*

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