THE THIRTY-SIXTH UBC PHYSICS OLYMPICS RULE BOOK

March 8, 2014

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

Version 3, 11 February 2014

General Rules

Each school may enter one team of students, which participates in all 6 events. A team may have a maximum of 15 registered students, of which at most 5 participate in a given event. 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 Union 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 traveling 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. The schools are ranked by their score in each event, and the decibel score for the event is $\mathrm{dB} = 10 \times \log_{10}(\mathrm{rank})$. Thus a first place ranking in an event is 0 dB, second is 3.01 dB, fifth is 6.99 dB, tenth is 10 dB, twentieth is 13.01 dB. The overall winner is 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 which, 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.

Pre-Build Events

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

The pre-built events are intended to be learning experiences for the students, so we ask that team coaches resist the urge to overly involve themselves in the 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 about 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. Thomas Mattison, preferably by email to mattison@physics.ubc.ca or by telephone 604-822-9690.

1. Anti-Brachistochrone / Time Machine

Your task is to construct a device which causes a ball to travel from one point to another in the greatest amount of time.

You will supply a spherical ball 25-35 mm in diameter to use with your device. Nothing may be attached to the ball. The ball may not have any active internal mechanisms.

Our timing system has a 50 x 50 cm plexiglass top plate, and a 50 x 50 cm plywood bottom plate, separated by 100 cm. The top plate has a 5 cm diameter hole in the centre for the ball to enter your device, and the bottom plate has a 5 cm diameter hole in the centre for the ball to exit your device. We will place your ball into a starting mechanism above the top plate, and release it. The start time is defined by a beam of light above the top plate, and the end point is defined by a beam of light below the bottom plate.

Your device must fit in the 50 x 50 x 100 cm region between the top and bottom plates. Your device may have no moving parts, except the ball. You may not interact with either your device or the ball. The ball must be visible to the judges at all times. The ball must have non-zero velocity or acceleration at all times. The ball is defined to have stopped if it moves less than 1 cm during any second.

If a ball is still moving after 5 minutes, we will measure how far below the top plate it has travelled, and calculate when it would reach the bottom plate, assuming constant vertical velocity.

The winner will be the device with the longest measured or extrapolated travel time. Devices in which the ball stops before the end point will be ranked below all measured or extrapolated times, by the vertical distance the ball has traveled (more is better).

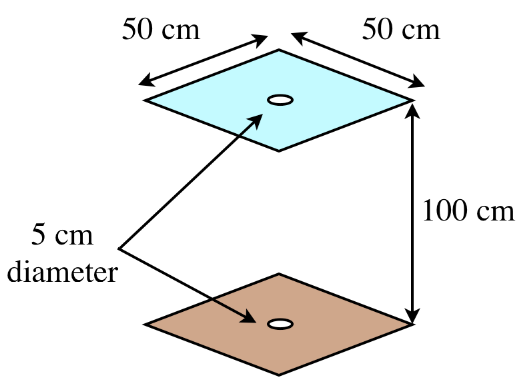

Figure 1: Top and bottom plates for Time Machine

2. Wind-Turbine Generator

Your task is to construct a wind-powered DC electrical generator device that produces the maximum amount of power.

Our wind source will be a household box fan, *e.g.*, “Likewise Box Fan, 20 Inch,” Canadian Tire product #43-5694-6. It will be on a table-top, and operated on its highest setting. You will place your device on the same tabletop.

Your device must be a self-supporting unit that fits within a 50 x 50 x 50 cm cube (including the airfoils, but excluding the output wires). No part of your device may be within 50 cm of the fan.

The generator unit can be a DC motor from a toy or other small device, or you could purchase a DC motor (a suitable motor will cost only a few dollars). The generator unit (excluding shaft and wires) must fit into a cylindrical volume of no more than 35 mm diameter and 35 mm long. The generator unit must be sufficiently visible in your device for this to be verified.

You may not purchase the airfoils for your device; you must construct them. You may use whatever design and materials you choose, and connect them to the generator in any way you choose.

Your device must have two output wires at least 1 meter long. The output wires will be connected (via alligator clips) to the V_+ and V_- terminals of the following circuit for the power measurement. The power produced by your device is the product of the output voltage $V_2 - V_0$ and the output current $I = (V_1 - V_0)/R_{\text{shunt}}$. The variable resistor R_{adj} may be set to whatever value you choose between 0 and 100 Ω.

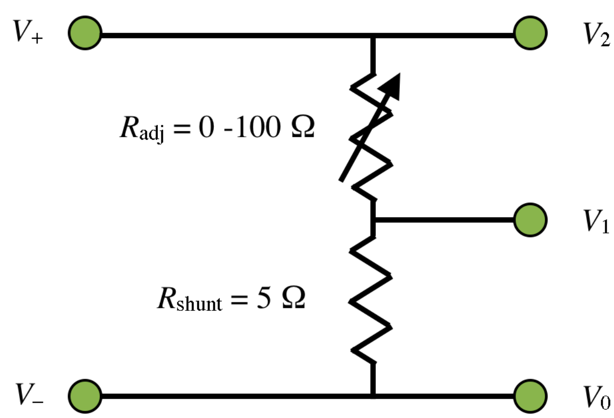

Figure 2: Measurement Circuit for Wind-Turbine Generator

Our fan and power measurement circuit will be running continuously. You will have a total of 3 minutes to put your device next to the fan, connect it to the circuit, make adjustments to your airfoils and R_{adj}, and declare that you are ready for the power measurement. We will then restart the measurement circuit, wait 10 seconds, and measure the power. You must then promptly remove your device to make way for the next team.

The device that produces the highest power is the winner.

3. Polarized Light Lab

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

4. Mystery Lab

A laboratory-based event. To preserve the mystery, 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 (except the last) 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. A correct answer (indicated by holding up a letter card) is worth 5 points, an incorrect answer (or failing to hold up a card within 5 seconds) loses 10 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