THE THIRTY-FIFTH UBC PHYSICS OLYMPICS RULE BOOK

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

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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, with up to 10 schools participating in each heat. 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. Orbital Motion Endurance

The goal is to sustain circular orbital motion of a weight on a string for the longest possible time, using only gravitational potential energy from descent of weights.

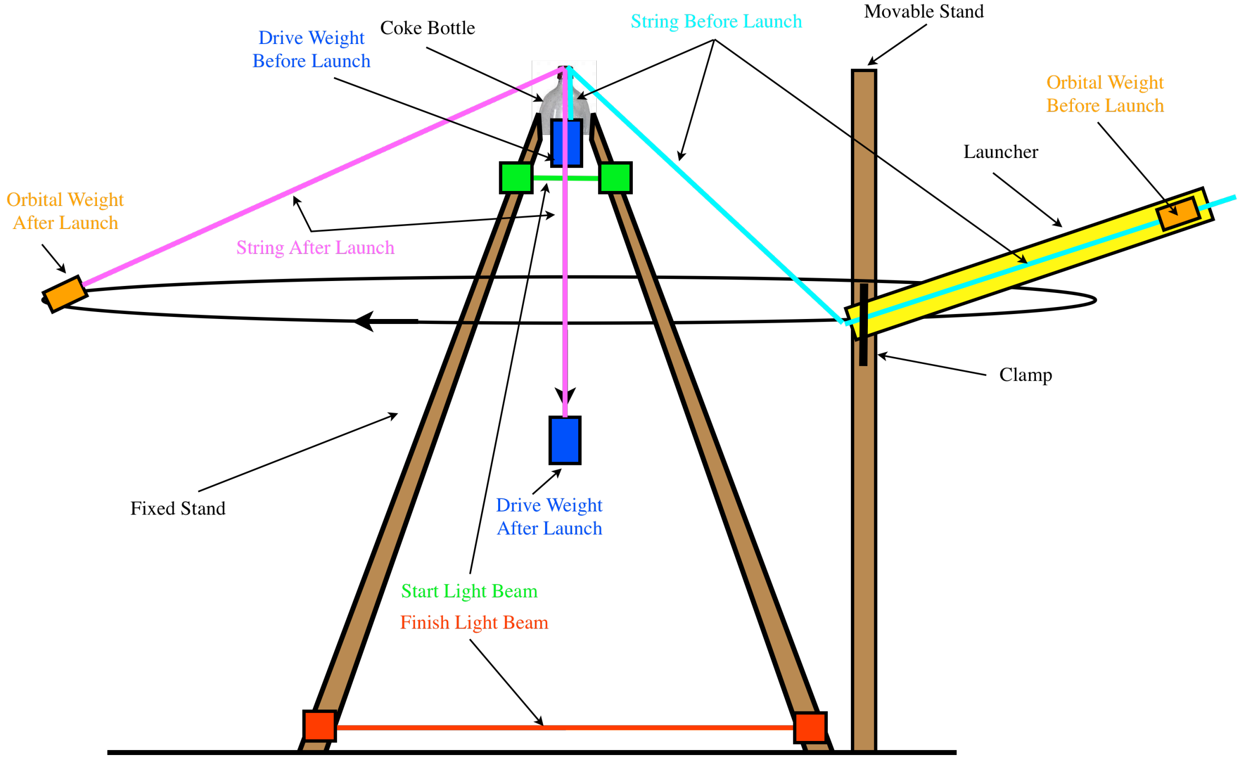

Figure 1: Orbital Endurance Setup

You will provide a drive weight, an orbital weight, a string between them, and a launching device for the orbital weight. We will provide a fixed stand that your orbital weight will revolve around, and from which your drive weight will descend. We will provide a movable stand that will clamp near the exit point of your launching device, which will be removed from the orbital path (along with your launching device) after the launch of the orbital weight.

You will thread your string through your launching device (with the attached orbital weight inside the launching device), then through the hole in the center of the fixed stand, where the drive weight will descend. We will clamp the exit end of your launching device to the movable stand to prevent it from moving during the launch. We will position the other end of the launcher manually per your instructions, and hold the orbital weight end of the string while the drive weight is attached to the other end. We will then release the orbital weight end of the string. The initial descent of the drive weight will cause the string to pull the orbital weight through your launcher, which will supply the initial orbital velocity. The orbital motion will develop tension in the string, which will slow the descent of the drive weight. An electronic timer will be started by the initial descent of the drive weight, and stopped when it reaches a point near the floor. The winning entry will be the one with the longest drive weight descent time, with the other weight still in orbital motion.

The fixed stand will support the top part of a 2 litre plastic Coke bottle at a height of 200 cm from the floor. Your string may touch the Coke bottle lip directly, or you may optionally provide a central pivot by modifying a screw top compatible with the Coke bottle. The light beam for the timer start will be 30 cm below the bottle lip, and the light beam for the timer finish will be 5 cm above the floor.

Your drive weight must fit within the volume of a 2 litre plastic Coke bottle (diameter < 10 cm, lower end < 25 cm from the bottle lip when hooked to the string). The sum of your drive weight, orbital weight, and string must be < 500 grams. Your string must be long enough so when the drive weight has reached the floor, the orbital weight is still orbiting. Your string must not have significant elasticity. Your string must pass freely through the stand, so the drive weight may descend freely. If the orbital radius is more than 200 cm, the orbital weight may hit an obstruction.

Your launching device may not provide energy to the orbital weight, except for conversion of gravitational potential energy of the weight(s) into kinetic energy. The initial position of the orbital weight within the launching device must be no more than 200 cm from the floor. Your launching device must be < 150 cm long, and the exit end must fit within an 8 cm diameter clamp. The clamp may be positioned between 100 and 200 cm from the floor, at any radius out to 200 cm. You are free to choose the orientation of your launching device. Your launching device will be held stationary until the orbital weight exits, then will be removed from the orbit radius.

You will have 4 minutes to set up your device, including positioning the launcher and orbital weight, and threading the string through the launcher and fixed stand. We will hold the launcher and the string coming out the end while you attach the drive weight. We will then release the string, which will result in the timer starting and stopping. You may choose to abort an attempt and try again, or irrevocably discard an attempt and try again, if still within the 4 minutes.

2. Hacky-Sack Launcher

The goal is to fabricate a launcher to accurately propel a Hacky-Sack or equivalent footbag projectile toward a target that is 5 metres away, using only gravitational potential energy.

The target is a 10.8 cm diameter hole in the centre of a 100 cm square box filled with birdseed. The birdseed level is 10 cm above the floor. Your score on a shot is the distance from the centre of the hole to the closest part of the footbag after it has come to rest, with a distance of 0 if the footbag comes to rest in the hole. A 50 cm penalty will be added for contacting the back or side walls of the target box, or the floor outside the target box. Your score for the event is the sum of the scores for your best 2 shots out of at most 5 attempts. If you make fewer than 2 shots, missing shots will be scored as 500 cm. Tie scores will be broken in favor of the launcher with the lowest total weight of all components.

Your launcher may have no source of stored energy except gravitational potential energy. Releases of stored electrical, chemical, elastic, hydraulic, pneumatic, nuclear, or zero-point energy are specifically disallowed. Your assembled launcher must fit inside a rectangular box with 50 cm x 50 cm base and 100 cm height. No part of your launcher may be within 5 metres of the center of the target at any time. No part of your launcher may be more than 100 cm from the floor at any time. You may not directly or indirectly touch your launcher or the footbag, except to set up the launcher and to trigger the release of gravitational energy which powers the launch. Your launcher may not be a purchased device or kit.

You will provide your own Hacky-Sack or equivalent footbag. You may make modest modifications to interface the footbag to your launcher, e.g., attach a string to it. At least 75% of the original surface of the footbag must remain exposed. The footbag must weigh between 40 and 60 grams after any modifications. You will have 4 minutes to set up your launcher, make at most 5 launch attempts (including the time required for us to measure how close your footbag was to the target), and remove your launcher.

Figure 2: Target for Hacky-Sack Launcher

3. Electrical Mystery Lab

A laboratory-based event involving DC electrical circuits, current, voltage, resistance, Ohm's Law and/or Kirchoff's Laws. Heats will be closed to all persons except the participants.

4. Optical Mystery Lab

A laboratory-based event involving reflection and refraction. Heats 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.

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 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. The first team to buzz must answer the question. An incorrect answer (or failing to answer within 30 seconds) loses 5 points, and allows the other teams a chance to buzz to answer the same question. A correct answer is worth 5 points, plus a chance to answer a bonus question for 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 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