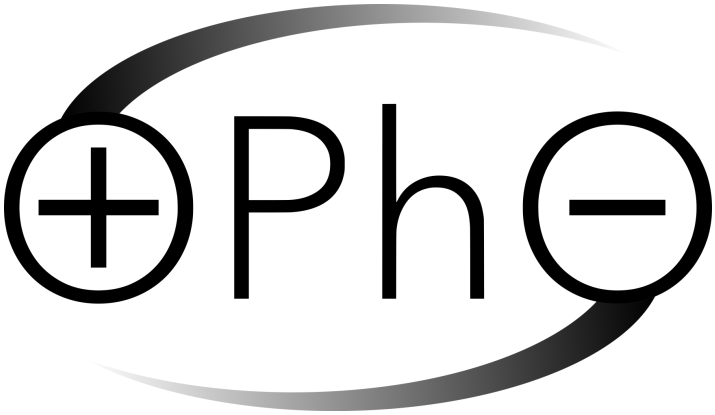


2020 OPhO Invitational Clarifications

MAJOR NOTES

- Hi everyone! **All team members are welcome to fill out this (optional) feedback form. Everyone who submits (and consents) will be entered in a draw to receive a $25 Amazon gift card.**
- Use this link to submit clarification requests. The problem writers may or may not deem it necessary to answer all clarification requests.
- Link to the overleaf template **(the link has been fixed)** for answer submission.
- **Reminder: There is only one final submission at the end of the competition via the submission form only. Do NOT email us a copy of your submission. In case of internet connectivity issues, any team member may email us the file.**
- Make sure to read over the instructions. You are expected to give symbolic answers unless *explicitly* otherwise stated. If the numerical values for a symbol are stated, you do not need to solve the problem for a general case.
- Uploading a .jpeg on the overleaf for a graph is allowed.
- **Please check the newest version v1.4 for revisions.**
- Please provide clear reasoning or derivations of any obscure results. Directly citing them would not necessarily fetch full points.
- We will be awarding a special prize for whichever team produces **the most creative and/or elegant solution** to certain problems. We will not be disclosing which problems until after the competition has concluded.
- Note on submission of solutions:

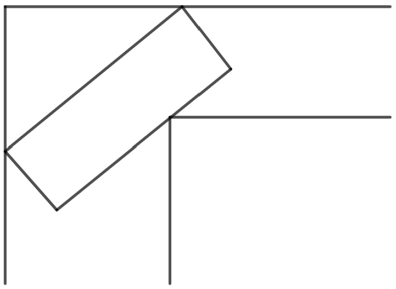
  It is highly recommended that the solutions to the invitational round be submitted in LaTeXed form. We recommend using Overleaf. It is preferred that the solutions are quite detailed; this

means that while you do not need to explicitly write all your algebra, all the relevant equations must be clearly written. A brief wording on how you solve a given system of equations is also optimal. Clearly state any approximations you make. Solutions typed in .doc/.docx, and ones neatly written by hand will also be accepted. Some students have a handwriting that's hard to read; if that's you, please read this. **You can submit solutions multiple times. Only the latest submission will count.**

Problem Notes

- Problem 1: The coefficient of friction (0.5 static, 0.3 kinetic) applies to the interaction of *all surfaces contacting the tablecloth and table* unless otherwise stated. **Note** that there was previously an incorrect clarification here, This applies to part b as well, and carries over to d. Since the speed of the table cloth is constant, find the speed of the tablecloth for parts a and b and d.
    - **This means the table + object(s) surface has friction.**
    - Assume a 4-wheeled car.
    - For the car, we are interested if the car remains on the table, no matter in which direction it falls off from
- Problem 2: Feel free to define any necessary variables such as power output of the sun, mass of the sun, etc.
    - Problem 2: b) Spherical shell means spherical full shell (hollow sphere), half the density refers to that as calculated from b
    - Problem 2: c) The initial conditions are picked such that if there were no radiation effects, it would be in a perfect circular orbit. The more accurately you can describe the orbit, the better. (mathematical representation would be better than qualitative)
    - Problem 2: d) use the sail from part c).
    - Problem 2: e)
        - assume solar sail maintains circular orbit around the sun
        - its spin angular speed is much greater than the orbital angular speed
        - express your answer in terms of sail radius r, sail mass m, orbital radius d, and fundamental constants. (d>>r)
- Problem 3: Assume that the resistivity and current are small, so that the potential does not vary significantly along the surface of the wire.
    - In part (b), "Now, the outer surface of the wire is maintained at a potential of V ≥ 0" is changed to "Now, the outer surface of the wire is maintained at a potential of -V, where V is positive."
    - The graph in part (e) should be created based on the formula derived in part (d)
- Problem 4: Assume that the coefficient of static and kinetic friction are the same. Also note that all energy losses are dissipated in the form of heat. Find the angular acceleration about the centre of the cylinder. You are required to find the total heat loss in the system till that point. (by the time the cylinder has rotated by an angle \phi) All the quantities stated in the problem are given.
    - Correction: "The shell gets stuck in the cylinder wall, after which the ~~shell~~ cylinder starts to move, slipping on the surface."
- Problem 5: Please use the setups given.
    - Problem 5 a)
        - Do not assume sin x ~= x for small x.

        - To be more flexible, we decided that we will not take off any marks if the object does not start from rest, as there may be multiple solutions.
    - Problem 5 b)
        - For “force balance”, you may choose to take into account forces and/or torques.
        - This is a diagram of the setup (not to scale), from the top down.



        - The solution *can* be numerical, though not necessarily. You may or may not need to use a graphing calculator for this question (but cannot for other questions).
    - Problem 5 c)
        - It is not necessary to use two circuits. You may use more or less, but the solution has to be based on circuitry.
        - You can upload an image of the circuit if needed.
- Problem 6:
    - Rotation is about the center.
    - An equilibrium angle corresponds to the angle with respect to the vertical where there is an equilibrium point.
        - Equilibrium points are defined with respect to the rotating reference frame of the Earth.
    - For part a, you are to find the value of angular frequency of small oscillations at each one of these equilibrium angles.
    - For part b, just to be clear, Investigate the stability of each equilibrium position with varying angular velocity of the Earth.
    - For part c, make no assumptions of r>>l.
    - You can express your answers in terms of l if required.
    - The pendulum rotates with the Earth.
    - The pendulum is placed such that it does not touch the ground and oscillates (it is placed like a regular pendulum attached to a ceiling or you could imagine a person holding the pendulum over the center of the flat Earth).
    - The distance r the pendulum moves is in the horizontal direction. In other words, it moves a distance r on the surface of the flat Earth.
    - The flat Earth rotates about the z-axis.
    - For all parts you may assume the radius of the Earth R is large enough to be ignored.
- Problem 7:
    - Problem 7 a), the energy function has been changed from E = E_0 (x^r + y^r + z^r) to E = E_0 (|x|^r + |y|^r + |z|^r).
    - Problem 7 b), the wording is a bit vague. The particles can **only** exist at integer values of |x|,|y|,|z| < 2. (They cannot exist anywhere else).
    - Problem 7 c) The system is referring to the system in part (b).
        - (i) The distinct particles refer to distinct bosons.

- Problem 8:
    - Part A:
        1. P(r) is constant with time and over the sphere of radius r.
        2. For part (e), P_r is evaluated at the surface of the star. (at r = R_\odot)
        3. u(\nu) representing the energy density is the energy per unit volume for a given frequency interval between \nu and \nu + d\nu.
        4. For part (a), you are required to solve the integral yourself. Do NOT attempt to use an integral calculator for this purpose. If you're not familiar with how it must be solved, replace it as "I".
    - Part C:
        1. T_0 is replaced by "T_E" in part (g). T_0 is unknown and needs to be answered using previously known variables..
        2. Energy absorption, reflection or emission "from the shells" may take place. The shells cannot transmit any energy, however. The special rocks do not allow any reflection or absorption of energy in between the shells and do not emit any energy on their own.
        3. The atmosphere does not emit any radiation of its own, and only absorbs a fraction of what it receives from the star.
        4. For part h, T(r) represents the temperature as a function of r, and not the temperature gradient.
- Problem 9:
    1. t is arbitrary.
    2. In c), assume that all the particles still collide many, many times with the walls (during the time interval t), but the particles don't collide with each other (during the time interval t).
- Problem 10:
    - Part B: different scenario from part A (but same dipole and ring)
        - consider the ring to be fixed.
        - the dipole lies on the axis of the ring.
        - The current in the ring is initially 0, when it is placed at infinity.
        - Surface conductivity is measured in 1/ohm, unlike regular conductivity. Though not needed, a lot of contestants have asked us to define surface conductivity: it is simply the surface current density over the electric field.
        - In part (g), the tube has a radius R.
        - Ignore any radiation effects for all parts.

Other Notes

- Uploading images: View this link to find how to upload images on overleaf.
- You are allowed to mix LaTeX and handwritten PDFs for your answer sheet. Note that you need to write your solution to the problem alongside your final answers.
- You can use basic formulae related to topics on the IPhO syllabus without derivation but all other formulae which go beyond that must be derived.
- If you find that space is running out on your LaTeX file, try to use \newpage and see if that fixes it.