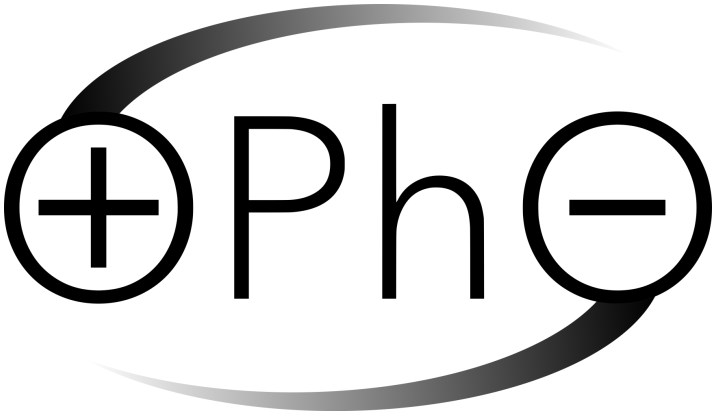


2021 OPhO Invitational Theory Clarifications

MAJOR NOTES

- **Last updated: August 14, 9:45 pm GMT**
- **Version 1.1 of the exam has been posted to the website.**
- We will only be adding clarifications that cannot already be found in the exam. If you are not seeing your clarification answered, try looking through the exam again to see if you did not miss anything.

Experimental Notes

- See: https://docs.google.com/document/d/1J8YSYlxc_2Lhu2sJIda_LVlpVbF9fAzRLdUseJiKDmk/edit

Problem Notes

- **T1**
  - **Part 1:**
  - For problem 1, neglect scattering forces completely in all subparts. Radiation forces are not negligible.
  - When finding the scattering force, the variation in z is neglectable.
  - For question 2, you may assume that x << W_0 and x~R.
  - The origin is the center of the optical tweezer.
  - You may assume all photons are directed in +z direction.
  - ~~The angular velocity of the nanosphere at t=0 is 0 in question 3.~~ EDIT: The following was wrong. You must consider the angular velocity of the nanosphere at t=0 to be w_0.
  - The torque obtained from a simplified model is not the general solution to part 2. You do not need to add contributions from part 2 to this part. If the torque is positive, it works to

increase omega. Furthermore, the time t described is asking during the entire process and not just after the turnoff, so you may express your answer as a piecewise function.
    - Torque is about the center of the sphere.
    - **Part 2:**
    - You only need to find upper and lower limits in question 4 and not general.
    - **The pipe does not conduct heat with its surroundings and is closed. The power that is put in the piston is dissipated by the wave. You may assume the rest of the energy from the wave is absorbed by the end of the pipe once the sound wave collides with it (reflection coefficient is 0).**
    - Air within the sound wave refers to the average temperature within the maximally compressed regions of the wave.
    - The answer for problem 4 does not need to be expressed in terms of the speed of sound. The gas is monatomic and ideal.
    - Delta rho is not a variable that you can use in this problem. However, you can use rho.
    - You have to consider a cylinder in question 6.
    - In question 6, there is no need to write a differential equation for when the pipe is vertical. We only ask for you to qualitatively describe where the cylinder is located and not quantitatively. The wave is moving so you can describe its general position as there will be multiple equilibrium locations and the cylinder will be oscillating.
- **T2**
    - For problem 2, you must approximate any expressions to first order given the assumption in the problem and then proceed. You do not need to use a first order approximation on β ~~but you may use it in any other approximations~~. (removed crossed out statement for ambiguity).
    - Whatever mathematical methods you use to show in part 1 does not matter as long as you are able to get the verified results.

- **T3**

    Moving Cylinders:
    - The thin groove does not affect the moment of inertia significantly.
    - The triangle frame is massless and rigid. The large cylinder only contacts the small cylinder at the distance alpha*r from the center of the small cylinder. The ground only contacts the small cylinder at the distance r from the center of the small cylinder.

    Windsurfing:
    - “Maximum possible sustainable” refers to the fact that the sailboat needs to stay in equilibrium.
    - This is a theoretical calculation: Do not assume any details about the sail’s geometry or operation. (You can design the sail however you want). The only limitations are that the sail intercepts an effective cross-section A of air (A is constant) and that the sailboat cannot generate or store energy.
    - F and u may not be parallel due to the long and thin shape of the sailboat’s bottom
    - Since the math is complicated, full credit will be awarded if you solve the problem numerically for a small value of gamma/(rho*A*v) (such as 0.05). Note that graphing calculators such as Desmos are allowed. The answer only depends on the variables provided.
- **T4**

    Part A
    - There seems to be a numbering issue. This will be fixed when the document is updated.

- “Find the energy of the circuit before the switch is open” is a typo. It should properly read: “Find the energy of the circuit when the switch is open”. C_1 is initially charged to V_0.
- Diameter of the cross-section of the current-carrying wire should be taken as D.
- In the first part, “fate of the remaining energy” refers to the calculation of E_Delta.
- Report the value of r in the last part of Fermi’s hypothesis. If the expression for E_Delta in Fermi’s hypothesis is left as an integral, it may not receive full points.
- All quantities must be calculated in terms of C1 and C2, not E_Delta unless specified.
- For Jackson’s hypothesis, r=0.
- Refer to the wikipedia page for the non-relativistic version of Larmor’s frequency, i.e, **do not use the formula given in the question paper** (this will be updated in the final version). The formula in the version 1.1 of the question paper is off, use P_r = \frac{2}{3} \cdot \frac{{\ddot{m}}^2}{4 \pi \epsilon_0 c^5}. Perform all calculations in SI units.
  Part B
- The initial surface charge density of the capacitor plates is **+/- sigma**.
- By “ideal capacitor”, we mean that the surface charge density of both the plates remains uniform. Also, the charges on the surface remain “fixed” to it as the capacitor plate is stretched.
- Calculation of dW for d << ka, b must be performed after finding an answer in the general scenario. You may submit the general answer in the form of an integral, or otherwise, whichever suitable.

Other Notes

- You are allowed to refer to Wikipedia (but not any other sources). You should typically rederive proofs instead of citing them.
- 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. If you desire a LaTeX template, we have made one for you here. Make a copy of the project to edit the document.
- 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.