Ph 212 Take-Home Exam Winter 2026

Below is a short-story of a scenario where you are president of the universe *Zaphod Beeblebrox*.

In order to answer several of the questions below you will need access to appropriate references. You may use any reference source you desire to complete this exam and you may collaborate with anyone while working on it. However, your final turned in solutions must be entirely your own work and, as always, you must always clearly show your thinking and how you derived your answers.

When you turn in your Take-Home exam, make sure that each question is submitted on its own page(s). There are eight problems each of which is worth 6 points. One of the problems must have a computational derived solution as well – any problem you solve computationally can be worth up to 2 additional points. To receive full credit you must not only provide the correct answer, but you must clearly and fully explain how you came up with that answer.

In order to aid the plot of the story, I've taken some "literary license" in the physics of the story. I've added some footnotes[1] at end to assist you in these situations and to give you hints in some areas. Have fun!

Your name is Zaphod Beeblebrox, and you are President of the Universe. You are aboard SpaceForce One headed toward the Solar System. Current plans are to dismantle Earth in order to make way for a hyperspatial express bypass. Your job as President is to shake hands, or fins rather, with the planet's most intelligent species known as Dolphins and see if they would be interested in turning the Solar System into a destination retirement suburb. Simply dismantling the Solar System's largest planet, Jupiter, could provide the raw materials to make what the Vogons would call a super-nifty retirement housing project that they want to call the Solar Suburb Dyson Sphere (SSDS).

1. The Vogon plan is to dismantle Jupiter for the raw materials needed to make the Solar Suburb Dyson Sphere (SSDS). The radius of the sphere is equal to Earth's current mean orbital radius with a density of $\rho_{shellmaterial}=3.0 g/cm^3$.
   a) How thick would the Solar Suburb Dyson Sphere be?
   b) What angular velocity will the SSDS have to be in order to provide inhabitants living on the equator of the sphere an apparent surface gravity of g_{earth}?
   c) What will be the total rotational kinetic energy of the shell?
   d) What will be the total angular momentum of the shell?

2. On Earth, seasons occur due to the tilt of our planet. a) Explain qualitatively the reasons for the seasons on Earth. b) Create a method of creating seasons in the SSDS – use a quantitative discussion to describe the effectiveness of at least one feature of the method.

[1] Extra-credit if you can make the scenario more realistic and fun.

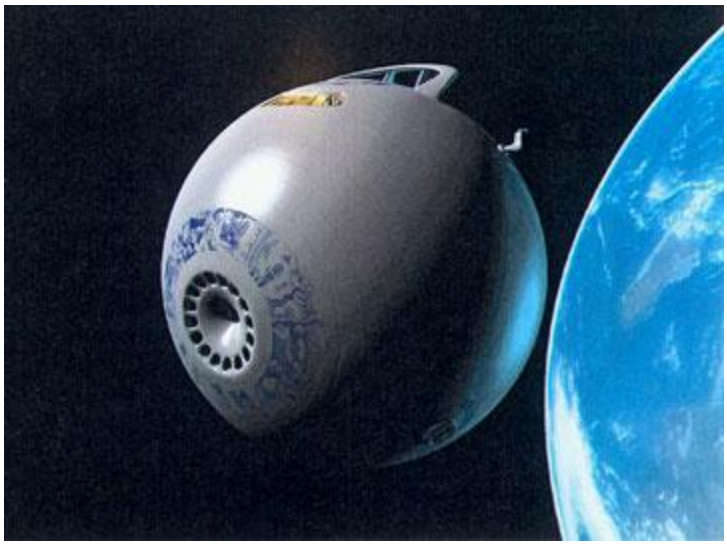
You come to a landing on Earth. Actually, it was more a splash-down than a landing as Earth's surface is made up of mostly ocean. "Why on Betelgeuse IV is this planet called Earth?" you ask yourself as your perfectly spherical ship is bobbing up and down in the perfectly calm ocean.

3. SpaceForce One is a perfectly spherical ship of mass $2.5 \cdot 10^6$kg and Radius 42meters bobbing up and down in calm seas on Earth At what frequency does SpaceForce ship bob? (As always, explain any approximations you make.)[2]

4. You speed across the surface of the Pacific Ocean at a speed of 0.2c.[3] Behind you there is a radio tower emitting radio waves at 550 on the AM dial, ahead of you is an identical radio tower emitting identical radio waves. You hear a beat pattern due to the Doppler Effect as you travel directly away from the first tower and directly toward the second tower. Meanwhile, Dolphin delegate floating stationary with respect to the two radio towers know that there "dead-zones" between the two towers. What is the period between beats you hear from your point of view? How long does it take for you to travel between the dead-zones from the reporters' point of view? Compare these two times and comment upon your result.

5. The Vogons have actually just moved into the Milky Way Galaxy. In 50 years their population has grown from 1000 inhabitants to 35000 inhabitants. Each Vogon consumes, on average, 10^6 kW-hrs of energy per Earth year. In how many years will the Vogons have to Dyson Sphere every sun in the Milky Way? As always, show all of your work.[4]

[2] Trust me here, you are going to want to make an approximation or two here or else the problem is going to get non-linear.
[3] The Dolphins love it when you, the President of the Universe, break local speed limit laws.
[4] It turns out that the Vogons, or something similar to them, may have already Dyson Sphered entire galaxies. Check out: http://iopscience.iop.org/article/10.1088/0067-0049/217/2/25/pdf



The real purpose you came to Earth and actually the real reason you became President of the Universe in the first place, was to steal the prototype ship "The Heart of Gold". The Heart of Gold travels via a "Planck Drive" and just happens to be on Earth this week to be serviced by a local species known as cats that are really good at being in a superposition of "love" and "hate" states at the same time. The propulsion system works by changing Planck's constant in a localized area. The great thing about a "Planck Drive" is that you can get from point A to point B without ever having to travel anywhere in between. You have positioned a Black Hole a distance of exactly 40 light-years away from Earth. If only you could get your hands on a second Black Hole you could make a resonant matter wave "box" where the Event Horizon of each Black Hole acts as the end of a quantum box. [5]

6. Being Zaphod, you are very apt at making friends. While hanging out with Mark and Sarah, two particularly fun members of the Dolphin species, you let them know about your plans to steal the Heart of Gold. Sarah points out you should just go ahead and take Mars, which no one is using right now, and turn it into a black hole. To what radius do you need to compress Mars in order to turn it into a black hole?

7. If the Heart of Gold has a mass of $M=5.00\cdot10^{9}$kg, a diameter of 137 meters, and relative velocity v=142km/h (88mph), to what value of do you need to adjust Planck's Constant in order to spontaneously teleport yourself into impregnable "Fort Knox" that happens to be exactly 10 light-years away from Congress' Blackhole at this moment?

[5] Ok, there has been a lot of "literary license" going on here. For example, the Planck Constant seems to be a constant (hence the name). There are probably even some greater physics issues here that are mangled, I dreamt this question up on the drive to school… thus, extra credit if you can make the question more realistic.

The Heart of Gold uses probability drive to travel. Everything in the vicinity of a probably drive tends to get to experience multiple realities all at once. In one reality, Mark and Sarah see themselves departing Earth waving "So Long and Thanks for All the Fish" as Earth gets dismantled to make way for the hyperspatial bypass. In another future, Sarah and Mark see that they have used the James Webb Telescope to spy on the Vogon commander as he plagiarizes the work of Paula Nancy Millsone Jennings of Sussex. Once it is learned that Paula truly creates the worst poetry in the known Universe, the destruction of Earth is put on indefinite hold. Sarah and Mark decide that this really is a better future. Together, they become strong advocates of biodiversity and dedicate their lives to the preservation of all species of planet Earth – even the annoying ones.

8. Explain how the Keck Telescope utilizes adaptive optics and then draw a "to-scale" ray diagram that demonstrates how the Keck Telescope on Mauna Kea brings the image of a far object to focus.

Exam Due Date and Time:
Please upload your completed work into GradeScope by noon on Thursday of finals week.

Scoring Rubric:
Each question is worth 6 points. Each of the below components must be present for each question you answered in order receive full credit for that question:

1pt Clearly original work following the basic problem-solving skills we covered in class is displayed.
1pt Assumptions made are clearly explained and appropriate for the problem.
1pt An easy-to-follow analysis of how you came upon your answer is provided.
1pt Any sources utilized, including study-group members, are clearly footnoted.
1pt A final answer is clearly displayed as well as a discussion of the ramifications of your result.
1pt Your final result is correct based upon the assumptions that you made.

You get two more points for the problem that you solved computationally.
If you solve more than one problem computationally, you can get extra credit.

Plagiarism Warning:
You are allowed to work with anyone on this exam and you may use any resource. However, all of the work you turn in must be your own. It is thus not acceptable for you, as a member of a group, to only work on one or two problems and then turn in the rest of the group's results as your own.

If you have any questions as to what constitutes plagiarism, please ask. However, in general, if any three words are copied verbatim then its source needs to be referenced and any equation that is used needs to be either empirical, derived or have its source fully cited.

Have fun and learn lots!