15th February 2020 11:00AM to 11:00 PM

Astro Sci-Comp GC

Krittika-The Astronomy Club of IIT Bombay

General Instructions

- The github repository from which you have downloaded this question paper will have the following files and folders
  1. This question paper having 4 pages, and a total of 4 questions
  2. A data-sheet with the relevant data for the problems, as well as a brief description of the data-sets
  3. A directory named `Data`, which has the required data-sets for the problems
- Questions 1, 2 and 4 are based on data analysis, and Question 3 requires the simulation of a given deterministic system.
- Solutions must be submitted by filling the form at this link. There are 3 parts to each solution:
  1. The final numbers/plots as asked in the form
  2. A brief description and justification of the methods used in the solution (there are marks for proper citation)
  3. The code used. (Will only be used to verify the answers. We will not be grading based on the code. However, if there is a mis-match between either the outputs of the code and the results, or with the method described in Part 2, then marks will be deducted)
- **Any assumptions made in the solutions must be stated with proper justification and/or citation, for full credit.**
- **The use of Internet is allowed**, as long as it is not used to communicate with anyone. Any violation of this rule may result in mark penalties or immediate disqualification, at the discretion of The Managers, Krittika.
- Each question has a hint associated with it, which a team can ask at any given point of time, at the loss of 25% of their score.
- Discussion within teams is allowed as long as it does not disturb other teams. To iterate, **no discussion is allowed between different teams**, regardless of hostel.

In the New Epoch of Humankind where information is the new currency (and where everyone has funny sounding names that sound strangely like a thinly veiled reference to someone else (what?)), a new kind of superpower emerges, the Novan Territory ruled by the Empress Ttriki, and governed by her Chief Scientist, Dr. Gwa Ratkar.

Framed by the infamous Chitania The Rebellious for the murder of one B'Nav, you Tripping Shar and Fazed Paje (real names withheld), are sentenced to life in space-time confinement. However, the legendary scientist Dr. Ysha Rma, comes out from her island moments before you are cast away into the cold darkness of space, and gives you her pocket super-computer PRTHM1, which allows you access to the extremely sought after Very Extensive Database of Archives from the Novan Territory, a repository of several useless facts, which could possibly guide you to the Capital City of BITI, where you can once and for all prove your innocence.

Your journey starts as you drift to sleep, meandering through the stars.

Problem 1

[25 marks]

> "The art of knowing is knowing what to ignore"
> - *Rumi*

You are woken up by PRTHM1 which informs you that you are now far enough from the Courts to escape detection, and are nearing a carefully selected Star-Planet System. Although PRTHM1 may guide you, it cannot outright tell you where you are or where S2707 is, even though the Very Extensive Database of Archives from the Novan Territory knows this information.

The star, KDS-10 has a planet named M'hrshi revolving around it. As you begin your search for BITI, you must choose a suitable spot to park your space-craft to maximize the amount of sky you can cover.

a) Choose a place to park your space-craft. (5)

Now that you have almost uninterrupted access to the sky, you begin your survey, and within 3 days, you spot what is surely the star hosting BITI. Now, you must find the distance to this star.
Suddenly, your parking is de-stablized. PRTHM1 informs you that the space-craft had been drifting away from its location for a while now, but it is clear that you must land on the planet M'hrshi. PRTHM1 using its infinite precision computational capabilities, lands you in a swamp. With no other choice, you muster on.
The only star whose distance PRTHM1 knows is the variable star V1509 from S2707. But PRTHM1 also knows that V1509 is a Cepheid Variable, with a Period-Luminosity relation (`given in the data sheet`), which means that you could find the distance to V1509 from your current position.

b) Find the distance to S2707. (20)

Question 2

[20 marks]

"Don't ignore these results"
- *Admin 1*

Now, faced with a possibility of dying from a hostile atmosphere if you open the hatch, you must first find the composition of the atmosphere. But without any atmosphere inside, you can't do that. Or can you?

In a rare moment of usefulness, the Very Extensive Database of Archives from the Novan Territory gives you a method to find the composition of the atmosphere. Compare the spectra of a star seen through the atmosphere, with the same star without the atmosphere. And since PRTHM1 has the standard spectrum of S2707 (without any extinction from ISM or the atmosphere), you can compare it with the data you record now, with the extinction, and identify the opacity of the atmosphere as a function of wavelength of light. PRTHM1 will find the elements present using this data.

a) Plot the opacity of the atmosphere as a function of wavelength (15)

b) Are any previous calculations affected by this? (5)

Question 3

[15 marks]

"The only thing we know for sure is that we dont't know anything for sure"
- *Albert Einstein* (maybe, you don't know for sure)

As you slowly begin to get used to the apparently great atmosphere of M'hrshi, the Very Extensive Database of Archives from the Novan Territory notifies you that this planet is the turf of SR.One, The Cosmic Hitman. Having had enough of this planet, you leave for S2707, and go back into cryostasis.

Once you wake up, it becomes clear that the star you thought was S2707 is not S2707, which makes everything you did till now absolutely useless, but instead of repeating any calculations, we try a new approach. Given that you know that BITI's orbital plane is aligned with the Galactic Disk, you decide to find it using the transit method, by checking each star that fits the profile of S2707.

a) Make a template light curve to show the dip when BITI transits S2707. (15)

Question 4

[35 marks]

Finally, you arrive at BITI, only to be stopped at the gate. Since information is the currency, the toll requires that you give them some information they require. (`plot armour lets the two convicted felons able to just walk into any airspace they want to`). Given the XRay Data, you must find if there is a GRB in the data and if so, when the GRB peaked.

a) Find if there is a GRB, and if so, when it peaked. (35)

Congratulations on making it to the end!
Or you skipped everything and came here first, in which case,
Congratulations on making it here!
The questions are designed to be slightly difficult to solve (they were difficult to make too, if that's any comfort), but keep at it, and Google like hell, and if you still feel like you need a boost, read the quote in the Data-Sheet.

-Admins 1 and 2 (and 0)