INDIAN INSTITUTE OF INFORMATION TECHNOLOGY, ALLAHABAD

C3 Application Problem: *Simulation of the Radiation field using the HIPARCOS data*, May 02, 2022.

Computational Astrophysics

B.Tech: (IT & ECE) Elective VI – Semester *QP: PC*

Full Marks - PART A: {1X16} + PART B: {5+6+14+5}=46 (Scaled to 10)

Time - 1hr, Max Time - 2hrs.

CALCULATORS/COMPUTER ALLOWED

Answers should be brief and to the point.

Unnecessary Extra writing will attract negative marks.

This C3 Assessment will be on an Application problem. The Assessment will be through a presentation by each group on the Application Problem which has been discussed in the class and provided well in advance for the students make their codes. Each group will be given 15min to present their work. **25 marks** out of **40** is reserved for the performance in the Simulation Problem. **15 marks** out of **40** is reserved for the ORAL question from the entire course taught to the students. This ratio of 25:15 may be varied in favour of the performance by the students so that the performance of the students could be maximized.

*On the Top of each paper/ code submitted by the student Group Should have the Name and Roll Number of all the Group Members. Students should should mention the involvement of each member of the group on different aspects of the Application Problem. (The Codes should have this portion put in the begining of each code under comment lines. All parameters of the code should be explained in these comment lines. The C-codes shared by me can be seen as examples. Proper visualization may be made to visualize the 3D data Cube with respect to the Galactic Coordinates (r, L, B). OpenGL/WebGL libraries may be used for the display. The data structure/data file should be in a DHF5 format (*Hierarchical Data Formats). The code could be in Python, C….

Students in groups of 5 should prepare a presentation
Do not share your login and password of your IITA e-mail. Any Malpractice of uploading through a single IP no, Uploading someone else's answer Sheet IS A CRIME. THE STUDENT will automatically fail the course.

These are difficult times. Your sincerity towards learning and ethical practice is expected from all of you.

PART-A

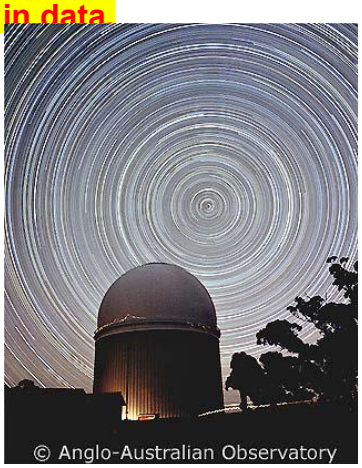
Short Question Short Answers (form Class Lectures) [Marks: 16X1=16].

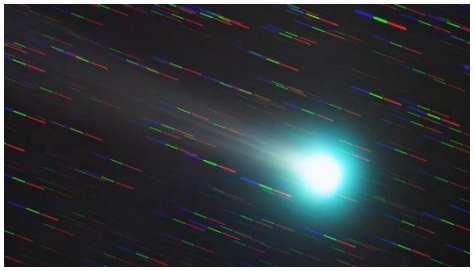
There will be marking the answer should be at least 75% correct to obtain 1 otherwise the marking will be 0.

1. Draw the pyramid showing the different layers of the pyramid moving from **Signal** to **Wisdom** (6Layers).
2. Write beside the pyramid what each layer is, what do they signify and what type of questions do these layers address how **Signal** is converted to **Wisdom**.
3. What condition should be fallowed during sampling of the signal?
4. What are the related field that help in Data Mining and Knowledge Discovery
5. What is more theory-based and is focused on testing hypotheses.
6. What is more heuristic. It is focused on improving performance of a learning agent and looks at real-time learning.
7. What integrates theory and heuristics; focuses on the entire process of knowledge discovery, including data cleaning, learning, and integration and visualization of results.
8. Knowledge Discovery in Data is the *non-trivial* process of identifying _____

***Valid, novel,* potentially *useful* and ultimately *understandable patterns* in data**

9. Why do we see the pattern in the sky shown in the photograph of the Anglo-Australian Observatory (**Fig. 01**)?



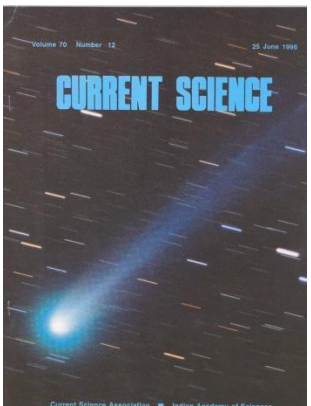


10.

11.

Fig. 04 Fig. 03 Fig. 02 Fig. 01

10. In the photograph taken by famous (**Fig. 04**), Astro-Photographer David Malin of the **Halley's Comet** (**Fig. 02**) during its last visit close to earth in 1986, we see streaks (lines) of **Red**, Green and **Blue**. While in the Photograph of the Orion Nebula (Fig. 03) by the same photographer does not show these Streaks. Why?



11. In the image of **Comet Hyakutake C/1996 B2**, taken 10 years later in 1996 by Dr Pavan Chakraborty which appeared on the front Cover of ***Current Science*** (*Vol. 79 No. 12 25 June 1996*) (**Fig. 05**) also shows the streaks as seen in **Fig. 02**. However, these streaks, do not show as seperate **Red**, Green and **Blue**. Why? (*The **Comet Hyakutake C/1996 B2** was travelling very close to the earth, therefor it had a high angular velocity in the sky. An SLR Camera with a 120mm Zoom lens, with Kodak Multi Film in it, was used for taking picture. The SLR Camera was mounted piggyback on the main 30inch Telescope at the Vainu Bappu Observatory. The Main 30inch Telescope which had a longer Focal ratio f/13 was used to guide on the comet's nucleus as the comet moved across the sky. Kodak Multi was a colour film with ISO 100 to 1000*).

Fig. 05

12. As mentioned above, **i)** what is the focal Length of the SLR Camera? **ii)** Focal Length of the 30inch Telescope with focal ratio f/13. iii) Plate Scale of the SLR Camera and 30inch Telescope in ***arcsec/mm***. (*1 arcsec = 1/3600 of a degree*; $\pi = 3.14159265359 = 180^{o}$).

13. Why Adding images after proper alignment, reduces noise while increasing the signal?

14. What is the best example where the above technique was used?

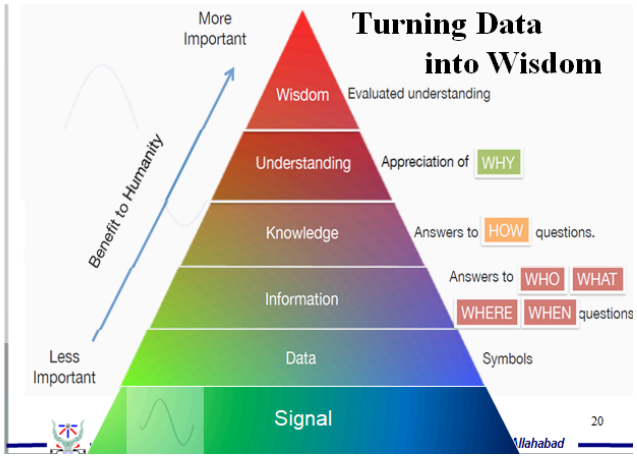
15. Hipparcos Catalogue was a high-precision catalogue of distances to the stars in our galaxy (more than 118,200 stars). This Hipparcos catalogue data was made using the Hipparcos Satellite. Images of the same region of the sky were taken 6 months apart and comparing these images the distance the stars where obtained. Draw the diagram and show how from the variation of position of the stars on the 6 months apart images reveals the distance to the stars.

16. ?

17. ?

18.

19.



20. The origins of the Two orthonormal coordinates (X,Y,Z) and (u,v,n) are separated by t_x, t_y, and t_z. Derive the transformation matrix from (X,Y,Z) to (u,v,n).

21. Give an example of a Change of Orthonormal Basis. Explain.

22. Draw the diagram with an ideal lens (of focal length f), imaging an object at a distance z ($f << z$). Using trigonometric relations, derive the perspective projection.

23. How is this transformation represented through affine/homogeneous transformation?

24. What do we obtain by normalizing ?

25. What is the "Look At" vector, the "Up" vector? What is the relation of these vectors with the camera coordinate?

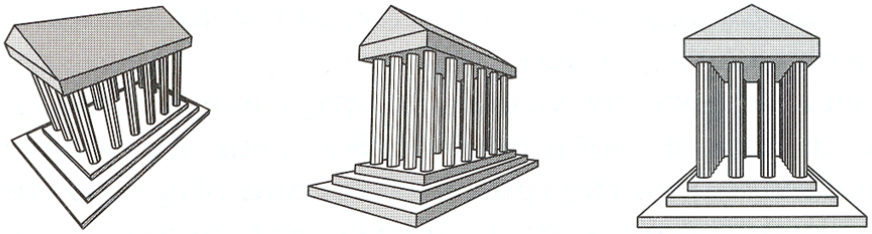
26. Derive the Camera Coordinates $(\hat{x}, \hat{y}, \hat{z})$ w.r.t. $\underline{LookAt}$ and $\underline{Up}$ vectors.

27. How many vanishing points? *{From Left to Right}*

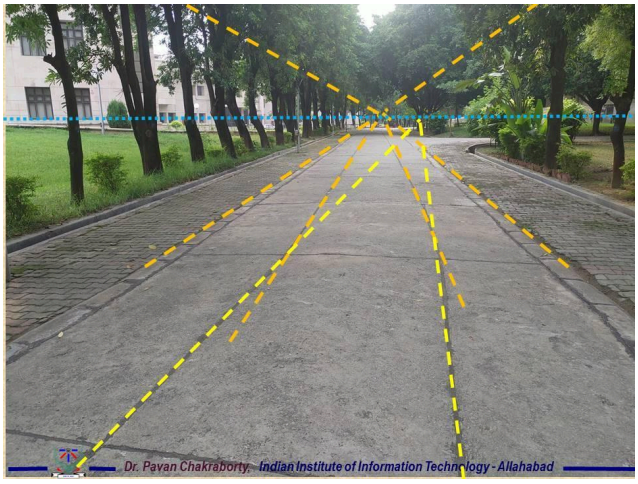
i) Fig(A) :

ii) Fig(B) :

iii) Fig(C) :



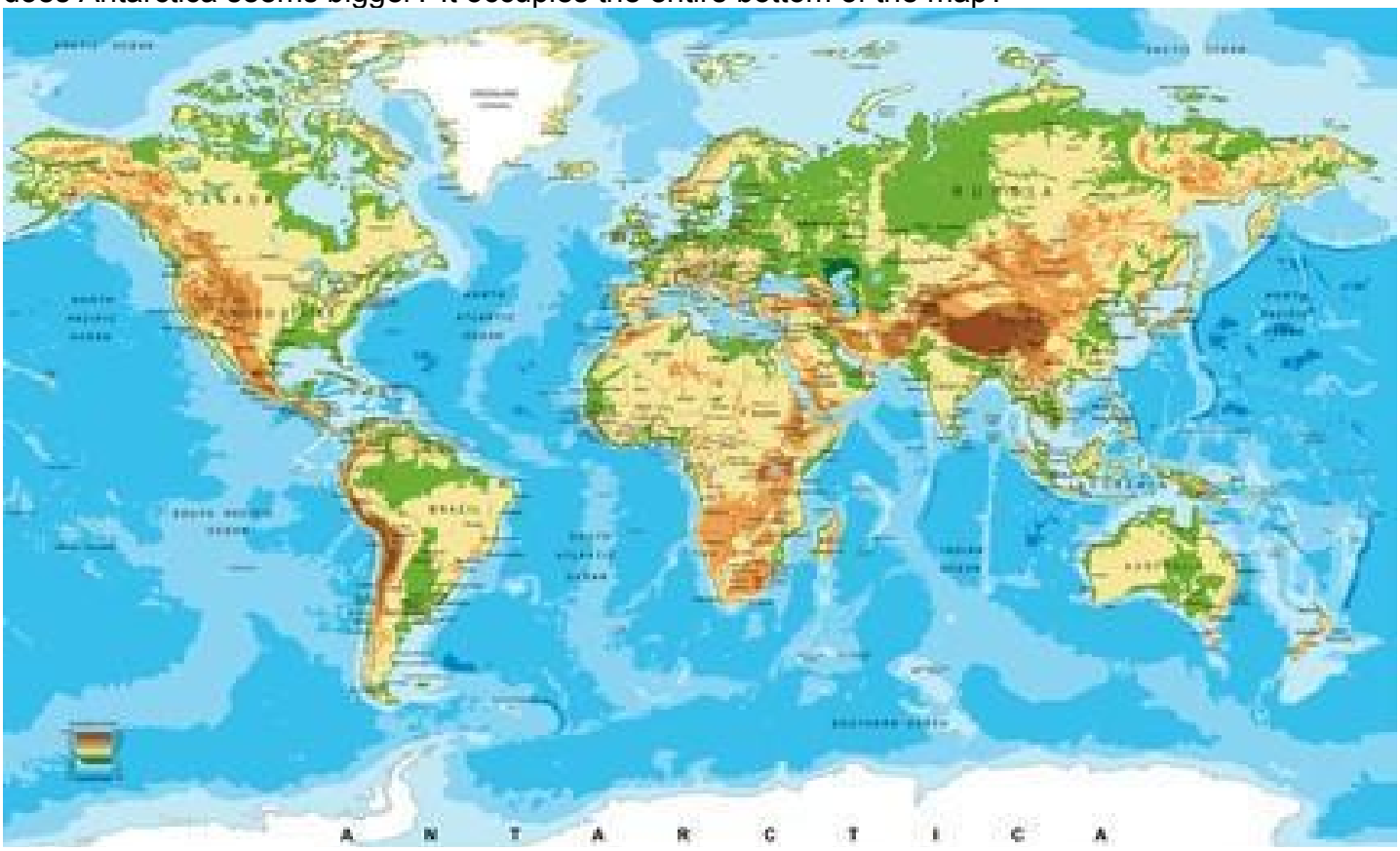
28. In this image of IIITA taken from CC-2 looking towards CC-1 the road shows 2-point Vanishing points (The Ocher lines and the yellow lines). Why do we see 2 vanishing points on the same straight road?



END of PART A **PART B in the Next page**

PART-B: PROBLEMS

1. During our High School we have all utilized an Atlas in our Geography class. We are all aware of 2 types of Maps (i.e. The Political Maps and the Physical Maps). Please Enumerate/Tabulate what information/Data is visualized in each of the types of Map. Also please mention how this Visualisation is made. We all know that Asia is the Largest Continent. Then but in the world map shown below, why does Antarctica seems bigger? It occupies the entire bottom of the map?



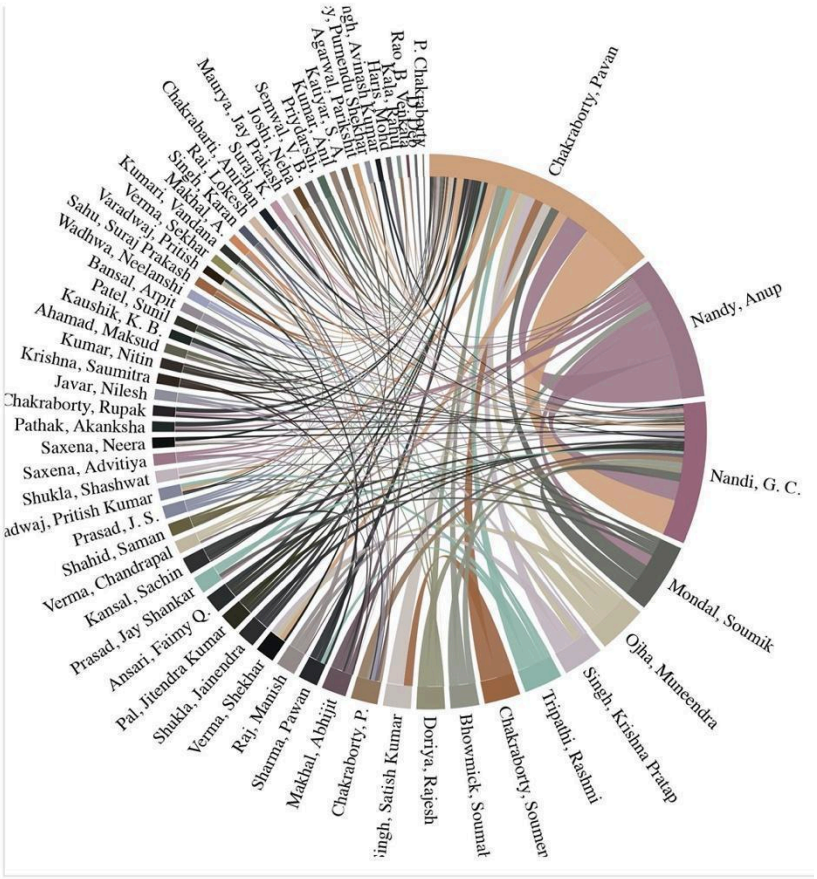
What does this map of India signify?

[3+1+1=5]

2. The figures shown on this page were extracted from:
https://iiita.irins.org/profile/102952

This web site is of INDIAN RESEARCH INFORMATION NETWORK SYSTEM. It is an Ministry of Education (MoE) Project: National Mission on Education through ICT (NME-ICT). The figures shows the research collaborations of Dr. Pavan Chakraborty (Myself). The 1st figure shows my research collaboration for last 10years from 2010 to 2020; While the 2nd figure shows my research collaboration in last 4 years 2017 to 2020.

a) Through this representation what information can you get?



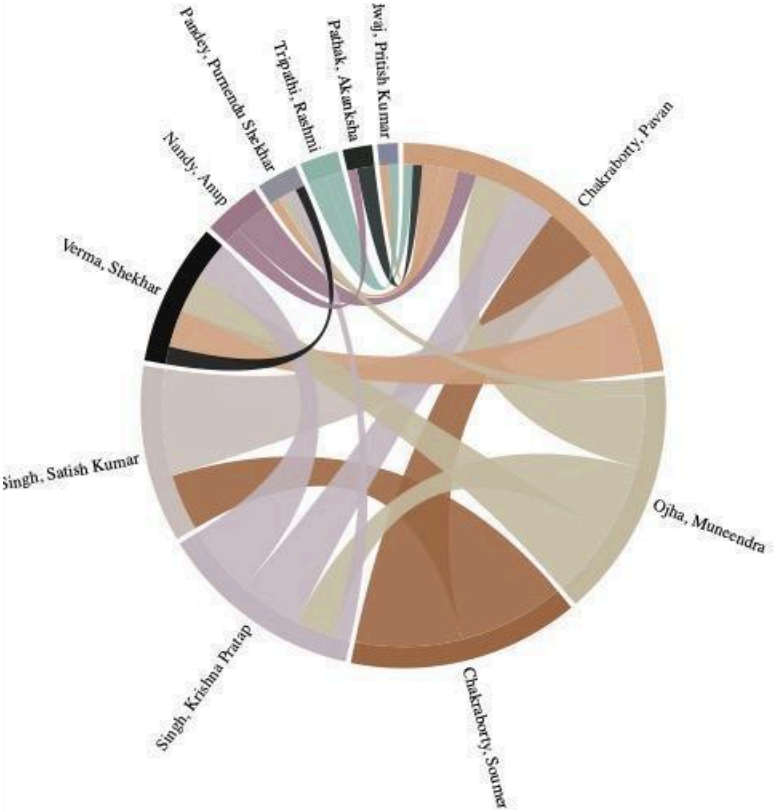
b) We Pick up 4 of my students, **Dr. Anup Nandy**, **Dr. Soumick Mondal**, **Dr. Moneendra Ojha** and **Dr. Sachin Kansal**. What can you state about my collaboration from with them from these 2 figures?

c) Visit the website:

https://iiita.irins.org/profile/102952

Change the tick marks beside the years 2010… 2020; and find out the approximate period of my research collaboration with my above 4 students.

[2+2+2=6]



3. A 3D cartesian plot. is visualized on a 2D paper/screen. The axis $\vec{x}$ and $\vec{y}$ of the 3D plot vary from 0 to +10 while the $\vec{z}$ axis varies from -5 to +15. All 3 axis are orthogonal to each other. This plot is viewed from (100,100,0). The "look at" point is (0,0,0) the origin of the plot. The $\vec{Up}$ vector is along the $\vec{z}$-axis. The plot is an orthogonal projection on the 2D paper/screen and the scaling is 1.0.

a) Compute the end vertex $(x, y)_{screen}$ of the axis lines $\vec{x}$, $\vec{y}$ and $\vec{z}$.

b) If the plot is viewed from (200,200,0), rest is the same then compute the end vertex $(x, y)_{screen}$.

c) If the plot is viewed from (100,100,100), rest is the same then compute the end vertex $(x, y)_{screen}$.

d) If the projection was perspective (as in question 3(a)) and $f = 10.0$, then what will be $(x, y)_{screen}$.

[4+1+4+5=14]

PRACTICAL LAB QUESTION: Submit it Separately.

4. Use a Butterworth low pass filter to remove noise from a sinusoidal signal using scipy package in python.

1. Signals made up of 30 Hz and 55 Hz .
2. Sampling frequency 2kHz. (use np.linspace() for creating time vector)
3. Order N=8 at 35Hz to remove 55Hz tone.

Use $y = 1 * \sin(2 \pi w_1 t) + 1 * \sin(2 \pi w_2 t)$ for the creation of signals.
Plot the signal before and after low pass filtering.
Send code in the classroom as .py file and also send output images of plots.

[5]