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M.Sc./III Sem.

PHYSICS

(Group A) Course XII (h)—Part I

(Astrophysics)

Time : 3 Hours   Maximum Marks : 50

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *All* questions.

1. Explorers discover a lost civilization in a remote island. They also find records of their astronomical observations. These indicate that on the day of the vernal equinox, they observed that the sun is in a particular direction which is at an angle of 60 degrees to the direction of the sun on vernal equinox today. They also find that the civilization existed for a brief period 4000 years ago. Estimate the time period of precession of the earth's axis.

6

2. An astronaut reaches a new planet X and stays for a year to make observations. She finds that planet X revolves around its axis and also goes around the Sun in a nearly circular orbit. At a latitude 30° she finds that the sun is overhead exactly once in the whole year. For latitudes less than 30° this happens twice a year :

(i) Calculate the angle of inclination of the rotational axis of the planet with respect to the orbital plane. Also calculate the latitude of the Arctic circle.

(ii) The observer sees a star passing through the Zenith. If the latitude of the observer is α, what is the declination angle of the star ? Assuming that all stars are uniformly distributed in the sky, what fraction of the stars will never be seen by the observer ? 7.

3. A star S at a distance of 4 astronomical units seems to move along an elliptical path in the sky with a time period of one year. The line joining the star and the sun makes 30 degrees with the normal to the plane of the earth's orbit. Calculate the values of the angular size of the semi-major and semi-minor axis of the ellipse. 9

4. The photons follow a zig-zag path from the center of the sun to the surface. So they do a random walk due to scattering and diffuse out of the star. Consider two stars of radii R_1 and R_2. Let the mean free path of the photons be r for both the stars.

    (i) If t_1 and t_2 are he times taken for the photons to start from the centre and emerge out, calculate the ratio $t_1 : t_2$.

    (ii) If the radiation density is the same in both the stars, compute the ratio of their luminosities. 6

5. The rotation curves of a spiral galaxy show that the circular velocity of the disk initially rises to a value v_0 at a distance r_0 from the centre and then increases very slowly as $v = v_0 + a (r - r_0)$. Calculate the density of matter as a function of radius in the region where the velocity varies very slowly. (Assume a spherically symmetric distribution of matter). 8

6. The line profile $I(\lambda)$ for radiation from the surface of a star is a Gaussian.

$$I(\lambda) \propto \exp\left(-\frac{(\lambda - \lambda_0)^2}{2\sigma^2}\right)$$

    What is the surface temperature of star ? 7

7. The apparent H-R diagram for free star-clusters is shown in figure 1. Which of them is the oldest cluster and which of them is the youngest ? (The reasons for the ordering should be mentioned.) If the distance of cluster 1 is L1, calculate from the figure the distance to clusters 2 and 3.
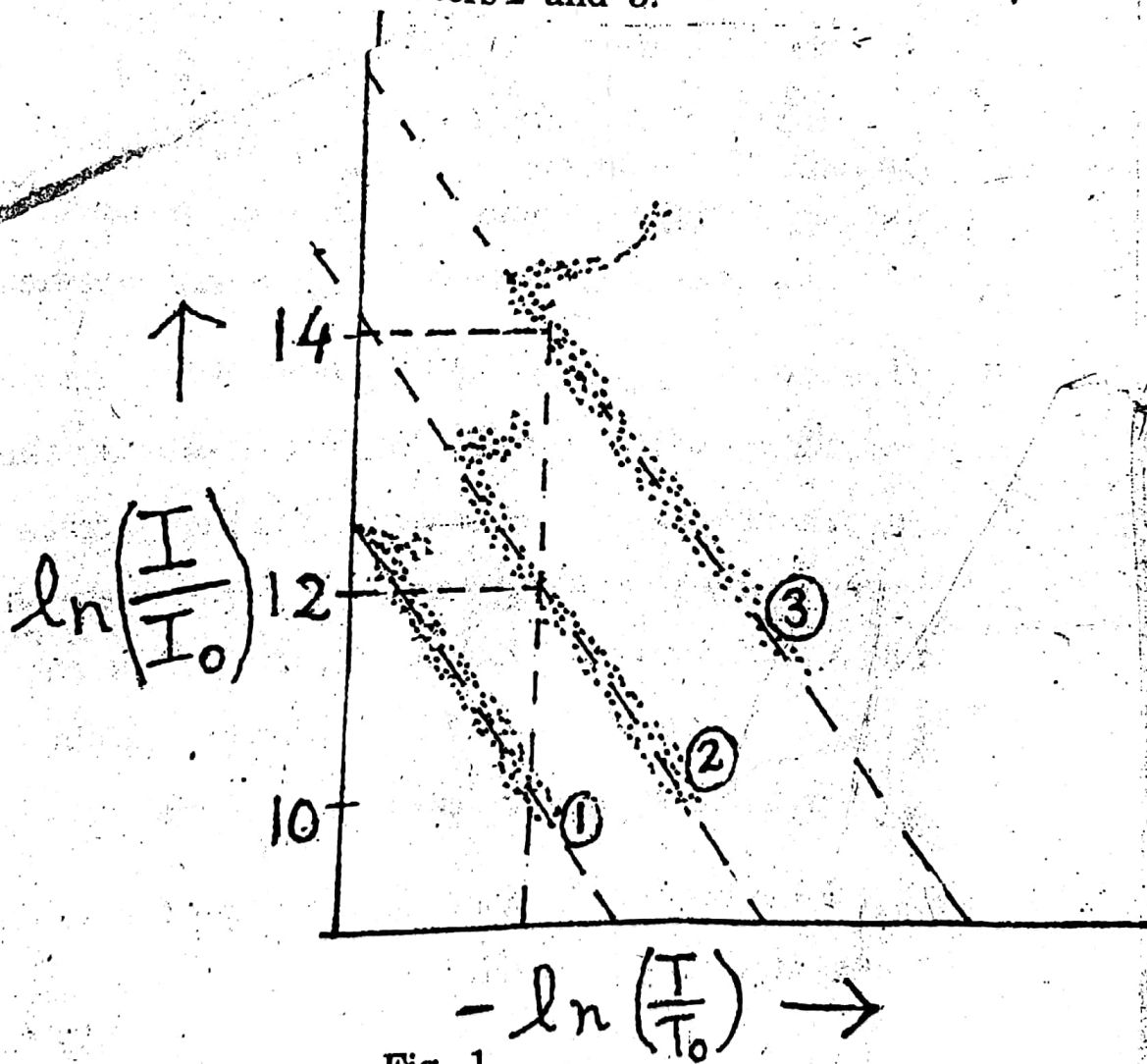
7

$\ln\left(\dfrac{I}{I_o}\right)$

14

12

10

$-\ln\left(\dfrac{T}{T_o}\right) \to$

Fig. 1

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