International Astronomy and Astrophysics Competition

Problem A: Reflector Telescope

Solution:

- (A) Secondary Mirror
- (B) Focuser
- (C) Eye Piece
- (D) Telescope Body
- (E) Primary Mirror
- (F) Mount
- (G) Outer Tripod Length
- (H) Tripod Support Brace
- (I) Tripod Leg Extension

Problem B: Distance to Alpha Centauri

Given:

- Real Sun diameter: $1,400,000$ km
- Real Earth diameter: $12,750$ km
- Real Earth–Sun distance: 1 AU $= 1.496 \times 10^8$ km
- Real distance to Alpha Centauri: 4.25 light-years $= 4.017 \times 10^{13}$ km
- Scaled Sun diameter: 22 cm

Scaling factor:

$$\text{Scaling factor} = \frac{22 \text{ cm}}{1.4 \times 10^6 \text{ km}} = 1.5714 \times 10^{-5} \text{ cm/km}$$

1. Scaled Earth Size:

$$\text{Scaled Earth Diameter} = 12750 \times 1.5714 \times 10^{-5} = 0.2 \text{ cm} = 2 \text{ mm}$$

2. Scaled Earth–Sun Distance:

$$\text{Scaled 1 AU} = 1.496 \times 10^8 \times 1.5714 \times 10^{-5} = 2.35 \times 10^3 \text{ cm} = 23.5 \text{ m}$$

3. Scaled Distance to Alpha Centauri:

$$4.017 \times 10^{13} \times 1.5714 \times 10^{-5} = 6.313 \times 10^8 \text{ cm} = 6,313 \text{ km}$$

Problem C: Density of Planets

(a) Derivation:

We know the average density:

$$\rho = \frac{M}{V}$$

By Newton's law of gravitation:

$$g = \frac{GM}{R^2} \Rightarrow M = \frac{gR^2}{G}$$

Volume of a sphere:

$$V = \frac{4}{3}\pi R^3$$

Substitute into ρ:

$$\rho = \frac{M}{V} = \frac{gR^2/G}{(4/3)\pi R^3} = \frac{3g}{4\pi GR}$$

(b) Calculation:
Given:

$$g = 9.81 \text{ m/s}^2, \quad R = 6.371 \times 10^6 \text{ m}, \quad G = 6.674 \times 10^{-11} \text{ m}^3/\text{kg/s}^2$$

$$\rho = \frac{3g}{4\pi GR} \approx 5510 \text{ kg/m}^3$$

Problem D: Cosmological Model

The Hubble parameter is:

$$H(t) = \frac{\dot{a}(t)}{a(t)}$$

Assume:

$$a(t) = \lambda t^\beta \Rightarrow \dot{a}(t) = \lambda\beta t^{\beta-1} \Rightarrow \ddot{a}(t) = \lambda\beta(\beta-1)t^{\beta-2}$$

Deceleration parameter:

$$q = -\frac{a(t)\ddot{a}(t)}{\dot{a}(t)^2} = -\frac{\beta-1}{\beta}$$

If $\beta > 1$, then $q < 0 \Rightarrow$ universe is accelerating.

Problem E: Comets

Comet Materials:

- Water ice (H_2O)
- CO_2 and CO ices
- Dust particles and silicates
- Organic compounds like CH_4 and NH_3

Behavior Near the Sun:
As a comet nears the Sun, its icy nucleus sublimates, releasing gas and dust to form the coma. The Sun's radiation and solar wind generate:

- Ion tail: straight, away from Sun (solar wind)
- Dust tail: curved, along orbit (sunlight pressure)

Thus, the bright tail is a result of solar energy interacting with volatile materials.