INTERNATIONAL ASTRONOMY AND ASTROPHYSICS COMPETITION

PROBLEM A: Reflector Telescope

Answer:

(A) Optical Tube (or Telescope Tube)

(B) Finder Scope

(C) Secondary Mirror (or Diagonal Mirror)

(D) Eyepiece

(E) Light Rays (from the observed object)

(F) Equatorial Mount (or Mount)

(G) Tripod Leg

(H) Tripod

(I) Counterweight

PROBLEM B: Distance to Alpha Centauri

Answer:

First, we need to establish our scaling factor. We're given the actual diameter of the Sun and its scaled diameter:

Actual Sun diameter: 1,400,000 km

Scaled Sun diameter: 22 cm

let's convert the scaled Sun diameter to kilometers: 22 cm=0.22 meters=0.00022 km

Scaling Factor=Scaled Sun Diameter/Actual Sun Diameter
Scaling Factor=0.00022 km/1,400,000 km
Scaling Factor = $1.57142857 \times 10^{-10}$

This tiny number tells us how much we need to shrink everything.

Next, we'll apply this scaling factor to find the scaled sizes and distances for the Earth, the Earth-Sun distance, and the distance to Alpha Centauri.

Actual Earth diameter: 12,750 km

Scaled Earth Diameter=Actual Earth Diameter×Scaling Factor
Scaled Earth Diameter=12,750 km×(1.57142857×10−10)
Scaled Earth Diameter = 2.00357×10^{-6} km

distance between the Earth and the Sun

Actual Earth-Sun distance (1 AU): 1.496×108 km

Scaled Earth-Sun Distance=Actual Earth
Sun Distance×Scaling FactorScaled

Earth-Sun Distance=(1.496×108 km)×(1.57142857×10−10)
Scaled Earth-Sun Distance = 0.0235028 km

distance to the nearest star (Alpha Centauri)

Actual distance to Alpha Centauri: 4.25 light-years

First, we need to convert light-years to kilometers. We know that 1 light-year is approximately 9.461×1012 km.

Actual Alpha Centauri Distance in km =
4.25 light_years×(9.461×1012 km/light_year)

Actual Alpha Centauri Distance in km≈4.020925×1013 km

Now, apply our scaling factor:

Scaled Alpha Centauri Distance=Actual Alpha Centauri Distance in km×Scaling Factor

Scaled Alpha Centauri Distance=(4.020925×1013 km)×(1.57142857×10−10)

Scaled Alpha Centauri Distance = 6320.15 km

PROBLEM C: Density of Planets

Answer:

(a) **: Showing the Equation for Average Density**

Explanation:

To derive the equation for the average density of a planet, we'll start with the two key formulas involved: Newton's Law of Universal Gravitation and the formula for the volume of a sphere.

First, the gravitational acceleration g at the surface of a planet is given by:

$$g=(GM)/R^2$$

Next, we know that density (ρ) is defined as mass (M) divided by volume (V):

$$\rho = M/V$$

$$V=(4/3)*\pi R^3$$
$$M = (gR^2)/G$$
$$\rho=(gR^2)/(V*G)$$
$$\rho=((gR^2)/G)/V$$
$$\rho=((gR^2)/G)/((4/3)*\pi R^3)$$
$$\rho= (3/(4\pi G))*(g/R)$$
$$\rho= (3/(4\pi G))*g*(1/R)$$

This derivation successfully shows that the average density of a planet can be calculated using the given equation.

(b): Calculating Earth's Average Density

Now, let's use the derived formula to calculate Earth's average density. We are given the following values:

Gravitational acceleration on Earth's surface (g): 9.81 m/s^2

Gravitational constant (γ or G): 6.674×10−11 m3/kg/s^2

Earth's radius (R): We need this value. The average radius of Earth is approximately 6.371×10^6 meters.

Let's plug these values into our derived equation:

$$\rho= (3/(4\pi G))*g*(1/R)$$

Substituting the numbers:

$$\rho=(3/(4\pi 6.674\times10^{-11}\ m3/kg/s^2))*(9.81\ m/s^2)\ /\ 6.371\times10^6\ m$$

First, calculate the term 3/(4πG) :

$$3/(4\pi(6.674\times10^{-11})) = 3.577\times10^9\ kg\cdot s2/m3$$

Next, calculate the term Rg :

$$6.371\times10^6\ m * 9.81\ m/s^2 = 1.5398\times10^{-6}\ s^{-2}$$

Now, multiply these two results:

$\rho \approx (3.577 \times 10^9 \ \text{kg} \cdot \ s^2/m^3) \times (1.5398 \times 10^{-6} \ s^{-2}) \ \rho = 5507 \ \text{kg}/m^3$

So, the Earth's average density, calculated using these values, is approximately 5507 kg/m3.

PROBLEM D: (was skipped due to the lack of skills on the concept)

PROBLEM E: Comets

Answer:

Materials Comprising a Comet

Comets are often described as "dirty snowballs" or "cosmic snowballs" because their nucleus is primarily a mixture of ice and dust. This nucleus is the solid, central part of the comet.

The main materials found in a comet's nucleus include:

Ices: These are volatile compounds that sublimate (turn directly from solid to gas) when heated by the Sun. The most abundant ice is water ice (H_2O), but comets also contain significant amounts of other frozen gases, such as carbon dioxide ice (CO_2), carbon monoxide ice (CO), methane ice (CH_4), ammonia ice (NH_3), and other organic volatiles. These are essentially frozen forms of common atmospheric and organic molecules.

Dust and Rocky Material: Embedded within these ices are microscopic silicate grains (rocky material), carbonaceous dust particles, and other non-volatile compounds. These are essentially fine particles of rock, metal, and organic molecules that don't vaporize easily.

Organic Compounds: Comets are rich in various complex organic molecules, including hydrocarbons, amino acids, and nitriles. These compounds are of great interest to scientists because they are considered the building blocks of life and could have been delivered to early Earth by comets.

Formation of the Bright Tail

The spectacular bright tail of a comet forms as it approaches the Sun.

Heating and Sublimation: As a comet's elliptical orbit brings it closer to the Sun, solar radiation begins to heat its icy nucleus. The ices within the nucleus, especially water ice, cannot remain solid at these temperatures and begin to sublinate directly into gas.

Formation of the Coma: The escaping gases carry along with them fine dust particles, creating a vast, glowing cloud around the nucleus called the **coma**. This coma can be hundreds of thousands of kilometers across, much larger than the solid nucleus itself. Sunlight reflecting off the dust particles and gases within the coma makes it visible.

Tail Formation due to Solar Wind and Radiation Pressure: As the comet continues its journey closer to the Sun, two distinct tails typically form, pushed away from the Sun by different forces:

Dust Tail: This tail is composed of the dust particles that were liberated from the nucleus along with the gases. Solar radiation pressure (the tiny push of sunlight) gently pushes these dust particles away from the Sun. Because dust particles are relatively heavy, they don't get pushed directly away from the Sun but tend to trail behind the comet in its orbit, often forming a broad, yellowish, curved tail. This is the tail that reflects sunlight, making it bright.

Ion (or Gas) Tail: This tail is formed from the ionized gases (plasma) in the coma. When ultraviolet radiation from the Sun strips electrons from the gas molecules, they become electrically charged (ions). These ions are then strongly pushed directly away from the Sun by the solar wind (a stream of charged particles continuously flowing from the Sun). Because the solar wind is much stronger than radiation pressure on these light ions, the ion tail is typically straighter, narrower, and appears blueish (due to emission from excited ions like carbon monoxide).

The "bright tail" often refers to the more prominent and visible dust tail, which shines by reflecting sunlight, though the ion tail can also be quite luminous. It therefore depends on factors such as the size of its nucleus, the amount of volatile ice it contains, and how close it gets to the Sun.