Least count of screw gauge = $\frac{\text{Pitch}}{\text{Number of divisions}}$

$= \frac{1}{1000} = 0.001 \text{ cm}$

Least count of an optical device = Wavelength of light ~ 10^{-5} cm

= 0.00001 cm

Hence, it can be inferred that an optical instrument is the most suitable device to measure length.

Question 2.7:

A student measures the thickness of a human hair by looking at it through a microscope of magnification 100. He makes 20 observations and finds that the average width of the hair in the field of view of the microscope is 3.5 mm. What is the estimate on the thickness of hair?

Answer

Preview from Notesale.co.uk
Page 7 of 31

Magnification of the microscope = 100

Average width of the hair in the field of view of the microscope = 3.5 mm

∴Actual thickness of the hair is $\frac{3.5}{100}$ = 0.035 mm.

Question 2.8:

Answer the following:

You are given a thread and a metre scale. How will you estimate the diameter of the thread?

A screw gauge has a pitch of 1.0 mm and 200 divisions on the circular scale. Do you think it is possible to increase the accuracy of the screw gauge arbitrarily by increasing

$$P = \frac{a^3 b^2}{\left(\sqrt{c}d\right)}.$$

$$\frac{\Delta P}{P} = \frac{3\Delta a}{a} + \frac{2\Delta b}{b} + \frac{1}{2}\frac{\Delta c}{c} + \frac{\Delta d}{d}$$

$$\left(\frac{\Delta P}{P}\times 100\right)\% = \left(3\times\frac{\Delta a}{a}\times 100 + 2\times\frac{\Delta b}{b}\times 100 + \frac{1}{2}\times\frac{\Delta c}{c}\times 100 + \frac{\Delta d}{d}\times 100\right)\%$$

$$= 3\times 1 + 2\times 3 + \frac{1}{2}\times 4 + 2$$

$$= 3 + 6 + 2 + 2 = 13\ \%$$

Percentage error in P = 13 %

Value of P is given as 3.763.

By rounding off the given value to the first decimal place, we get P = 3.8.

Question 2.14:

A book with many printing errors contains four different formulas for the displacement y of a particle undergoing a certain periodic motion:

Preview from Notesale.co.uk
Page 13 of 31

$$y = a\sin\left(\frac{2\pi t}{T}\right)$$

$y = a \sin vt$

$$y = \left(\frac{a}{T}\right)\sin\frac{t}{a}$$

$$y = \left(a\sqrt{2}\right)\left(\sin\frac{2\pi t}{T} + \cos\frac{2\pi t}{T}\right)$$

(a = maximum displacement of the particle, v = speed of the particle. T = time-period of motion). Rule out the wrong formulas on dimensional grounds.

Answer

an angle of $1''$.

$\therefore$ We have $\theta = \dfrac{r}{D}$

$$D = \frac{r}{\theta} = \frac{1.5\times10^{11}}{4.847\times10^{-6}}$$
$$= 0.309\times10^{-6} \approx 3.09\times10^{16} \text{ m}$$

Hence, 1 parsec $\approx 3.09 \times 10^{16}$ m.

Question 2.20:

The nearest star to our solar system is 4.29 light years away. How much is this distance in terms of parsecs? How much parallax would this star (named *Alpha Centauri*) show when viewed from two locations of the Earth six months apart in its orbit around the Sun?

Answer

Preview from Notesale.co.uk
Page 19 of 31

Distance of the star from the solar system = 4.29 ly

1 light year is the distance travelled by light in one year.

1 light year = Speed of light × 1 year

$= 3 \times 10^{8} \times 365 \times 24 \times 60 \times 60 = 94608 \times 10^{11}$ m

$\therefore$ 4.29 ly = 405868.32×10^{11} m

$\because$ 1 parsec = 3.08×10^{16} m

$\therefore$ 4.29 ly = $\dfrac{405868.32\times10^{11}}{3.08\times10^{16}}$ = 1.32 parsec

Using the relation,

$$\theta = \frac{d}{D}$$

where,

Diameter of Earth's orbit, $d = 3 \times 10^{11}$ m

Distance of the star from the Earth, $D = 405868.32 \times 10^{11}$ m

$$\therefore \theta = \frac{3 \times 10^{11}}{405868.32 \times 10^{11}} = 7.39 \times 10^{-6} \text{ rad}$$

But, 1 sec = 4.85×10^{-6} rad

$$\therefore 7.39 \times 10^{-6} \text{ rad} = \frac{7.39 \times 10^{-6}}{4.85 \times 10^{-6}} = 1.52''$$

Question 2.21:

Precise measurements of physical quantities are a *need* of science. For example, to ascertain the speed of an aircraft, one must have an accurate method to find its positions at closely separated instants of time. This was the actual motivation behind the discovery of radar in World War II. Think of different examples in modern science where precise measurements of length, time, mass etc. are needed. Also, wherever you can, give a quantitative idea of the precision needed.

Preview from Notesale.co.uk
Page 20 of 31

Answer

It is indeed very true that precise measurements of physical quantities are essential for the development of science. For example, ultra-shot laser pulses (time interval ~ 10^{-15} s) are used to measure time intervals in several physical and chemical processes.

X-ray spectroscopy is used to determine the inter-atomic separation or inter-planer spacing.

The development of mass spectrometer makes it possible to measure the mass of atoms precisely.

Question 2.22:

Just as precise measurements are necessary in science, it is equally important to be able to make rough estimates of quantities using rudimentary ideas and common observations.

$$= \frac{4}{3} \times \frac{22}{7} \times \left(7.0 \times 10^8\right)^3$$

$$= \frac{88}{21} \times 343 \times 10^{24} = 1437.3 \times 10^{24} \text{ m}^3$$

Density of the Sun = $\frac{\text{Mass}}{\text{Volume}} = \frac{2.0 \times 10^{30}}{1437.3 \times 10^{24}} \sim 1.4 \times 10^3 \text{ kg/m}^3$

The density of the Sun is in the density range of solids and liquids. This high density is attributed to the intense gravitational attraction of the inner layers on the outer layer of the Sun.

Question 2.24:

When the planet Jupiter is at a distance of 824.7 million kilometers from the Earth, its angular diameter is measured to be $35.72''$ of arc. Calculate the diameter of Jupiter.

Answer

Preview from Notesale.co.uk
Page 23 of 31

Distance of Jupiter from the Earth, $D = 824.7 \times 10^6$ km $= 824.7 \times 10^9$ m

Angular diameter = $35.72'' = 35.72 \times 4.874 \times 10^{-6}$ rad

Diameter of Jupiter = d

Using the relation,

$$\theta = \frac{d}{D}$$

$$d = \theta D = 824.7 \times 10^9 \times 35.72 \times 4.872 \times 10^{-6}$$

$$= 143520.76 \times 10^3 = 1.435 \times 10^5 \text{ km}$$

Question 2.25:

A man walking briskly in rain with speed v must slant his umbrella forward making an angle θ with the vertical. A student derives the following relation between θ and v: tan θ =