CBSE Test Paper 01

Chapter 2 Units and Measurements

1. The number of significant digits in 6.320 J is **1**

   a. 6
   b. 4
   c. 3
   d. 5

2. Newton is the SI unit of **1**

   a. acceleration
   b. work
   c. power
   d. force

3. The dimensions of Kinetic energy is same as that of **1**

   a. Pressure
   b. Work
   c. Momentum
   d. Force

4. A new unit of length is chosen such that the speed of light in vacuum is unity. What is the distance between the Sun and the Earth in terms of the new unit if light takes 8 min and 20 s to cover this distance? **1**

   a. 500
   b. 450
   c. 600
   d. 550

5. The number of significant digits in 0.0006032 m^2 is **1**

   a. 4

b. 6
c. 5
d. 3

6. Define S.I. unit of solid angle? **1**

7. How many light years make 1 parsec? **1**

8. Is it Possible to have length and velocity both as fundamental quantities? Why? **1**

9. The principle of 'parallax' in section 2.3.1 is used in the determination of distances of very distant stars. The baseline AB is the line joining the Earth's two locations six months apart in its orbit around the Sun. That is, the baseline is about the diameter of the Earth's orbit = 3×10^{11}m. However, even the nearest stars are so distant that with such a long baseline, they show parallax only of the order of 1" (second) of arc or so. A parsec is a convenient unit of length on the astronomical scale. It is the distance of an object that will show a parallax of 1" (second) of arc from opposite ends of a baseline equal to the distance from the Earth to the Sun. How much is a parsec in terms of meters? **2**

10. The resistance R is the ratio of potential difference V and current I. What is the percentage error in R if V is (100 ± 5) V and I is (10 ± 2) A? **2**

11. The Sun's angular diameter is measured to be 1920". The distance r of the sun from the earth is 1.496×10^{11} m. What is the diameter of the Sun? **2**

12. A great physicist of this century (P.A.M. Dirac) loved playing with numerical values of Fundamental constants of nature. This led him to an interesting observation. Dirac found that from the basic constants of atomic physics (c, e, mass of electron, mass of proton) and the gravitational constant G, he could arrive at a number with the dimension of time. Further, it was a very large number, its magnitude being close to the present estimate on the age of the universe (15 billion years). From the table of fundamental constants in this book, try to see if you too can construct this number (or any other interesting number you can think of). If its coincidence with the age of the universe were significant, what would this imply for the constancy of fundamental constants? **3**

13. The farthest objects in our Universe discovered by modern astronomers are so distant that light emitted by them takes billions of years to reach the Earth. These objects (known as quasars) have many puzzling features, which have not yet been satisfactorily explained. What is the distance in km of a quasar from which light takes 3.0 billion years to reach us? **3**

14. A book with many printing errors contains four different formulas for the displacement y of a particle undergoing a certain periodic motion:
(a = maximum displacement of the particle, v = speed of the particle. T = time-period of motion). Rule out the wrong formulas on dimensional grounds. **3**

    i. $y = \alpha \sin\left(\frac{2\pi t}{T}\right)$
    ii. y = a sin vt
    iii. $y = \left(\frac{a}{T}\right) \sin \frac{t}{a}$
    iv. $y = (a\sqrt{2}) \left(\sin \frac{2\pi t}{T} + \cos \frac{2\pi t}{T}\right)$

15. The diameter of a wire as measured by a screw found to be 1.328,1.330,1.325, 1.326,1.334 and 1.336 cm. Calculate **5**

    i. mean value of diameter
    ii. absolute error in each measurement
    iii. mean absolute error
    iv. fractional error
    v. percentage error
    vi. diameter of wire.

Answer

1. b. 4

   Explanation: There are three rules on determining how many significant figures are in a number:

   - Non-zero digits are always significant.
   - Any zeros between two significant digits are significant.
   - A final zero or trailing zeros in the decimal portion ONLY are significant.

   So keeping these rules in mind, there are 4 significant digit.

2. d. force

   Explanation: The newton is the SI unit for force; it is equal to the amount of net force required to accelerate a mass of one kilogram at a rate of one meter per second squared.

3. b. Work

   Explanation: Work

4. a. 500

   Explanation: Distance between the Sun and the Earth = Speed of light $\times$ Time taken by light to cover the distance
   Given that in the new unit,
   speed of light = 1 unit
   Time taken, t = 8 min 20 s = 500 s Distance between the Sun and the Earth = 1 x 500 = 500 units

5. a. 4

   Explanation: There are three rules on determining how many significant figures are in a number:

   - Non-zero digits are always significant.

- Any zeros between two significant digits are significant.
- A final zero or trailing zeros in the decimal portion ONLY are significant.

So keeping these rules in mind, there are 4 significant digit.

6. One steradian is defined as the angle made by a spherical plane of area 1 square meter at the centre of a sphere of radius 1m.

7. One parsec is equal to about 3.26 light years.

8. No, since length is fundamental quantity and velocity is the derived quantity and is derived from length and time.

9. Diameter of Earth's orbit $= 3 \times 10^{11}\mathrm{m}$
Radius of Earth's orbit, $r = 1.5 \times 10^{11}\mathrm{m}$
Let the distance parallax angle be $1'' = 4.847 \times 10^{-6}\mathrm{rad}$
Let the distance of the star be D.
Parsec is defined as the distance at which the average radius of the Earth's orbit subtends an angle of 1".
$\therefore$ We have $\theta = \frac{r}{D}$
$D = \frac{r}{\theta} = \frac{1.5\times10^{11}}{4.847\times10^{-6}}$
$= 0.309 \times 10^{17} \approx 3.09 \times 10^{16}\mathrm{m}$
Hence, 1 parsec $\approx 3.09 \times 10^{16}\mathrm{m}$

10. Percentage error = $\frac{\Delta R}{R} \times 100 = \pm\left[\frac{\Delta V}{V} + \frac{\Delta I}{I}\right] \times 100$
$= \pm\left[\frac{5}{100} + \frac{2}{10}\right] \times 100$
= ±25%

11. It is given that angular diameter, θ = 1920" and distance of the sun from earth, r =1.496×10^{11} m.
Now let the diameter of sun = d meters
$\theta = 1920'' = 1920 \times 4.85 \times 10^{-6}$
= 9.31×10^{-3} rad
Since, d = θr
Therefore, d = $9.31 \times 10^{-3} \times 1.496 \times 10^{11} = 1.39 \times 10^{9}\mathrm{m}$

Thus, the diameter of the sun is 1.39×10^9 m

12. Paul Dirac was a British theoretical physicist who made fundamental contributions to the development of quantum mechanics, quantum field theory and quantum electrodynamics, and is particularly known for his attempts to unify the theories of quantum mechanics and relativity theory.
One relation consists of some fundamental constants that give the age of the Universe by:
$= \left(\frac{e^2}{4\pi\varepsilon_0}\right)^2 \times \frac{1}{m_p m_e^2 c^3 G}$
Where,
t = Age of Universe
e = Charge of electrons = $1.6 \times 10^{-19} C$
ε_0 = Absolute permittivity
m_p = Mass of protons = 1.67×10^{-27} kg
m_e = Mass of electrons = 9.1×10^{-31} kg
c = Speed of light = 3×10^8 m/s
G = Universal gravitational constant $= 6.67 \times 10^{11}\,\mathrm{Nm^2 kg^{-2}}$
Also, $\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ Nm^2/C^2
Substituting these values in the equation, we get
$t = \frac{(1.6\times10^{-19})^4 \times (9\times10^9)^2}{(9.1\times10^{-31})^2 \times 1.67\times10^{-27} \times (3\times10^8)^3 \times 6.67\times10^{-11}}$
$= \frac{(1.6)^4 \times 81}{9.1\times1.67\times27\times6.67} \times 10^{-76+18+62+27-24+11} s$
$= \frac{(1.6)^4 \times 81}{9.1\times1.67\times27\times6.67\times365\times24\times3600} \times 10^{-76+18+62+27-24+11} years$
$\approx 6 \times 10^{-9} \times 10^{18}$ years
= 6 billion years
(which is the approximate age of our universe)

13. Time taken by a quasar light to reach Earth = 3 billion years
$= 3 \times 10^9$ years [since, 1 billion = 10^9]
$= 3 \times 10^9 \times 365 \times 24 \times 60 \times 60 s$ [since 1 year = 365 days = 365 $\times$ 24 $\times$ 60 $\times$ 60 sec]
We know that, speed of light = 3×10^8 m/s

Now, distance between the Earth and a quasar (using the formula, distance = speed of light × time taken by the light to reach the earth)

$= (3 \times 10^8) \times (3 \times 10^9 \times 365 \times 24 \times 60 \times 60)$

$= 283824 \times 10^{20}\,\mathrm{m}$

$= 2.83 \times 10^{22}\,\mathrm{km}$

This is the required distance between earth and a quasar.

14. a. Correct

$y = \alpha \sin \frac{2\pi t}{T}$

Dimension of y = $M^0L^1T^0$

Dimension of a = $M^0L^1T^0$

Dimension of $\sin \frac{2\pi t}{T} = M^0L^0T^0$

$\because$Dimension of L.H.S = Dimension of R.H.S

Hence, the given formula is dimensionally correct.

b. Incorrect

y = a sin vt

Dimension of y = $M^0L^1T^0$

Dimension of a = $M^0L^{-1}T^0$

Dimension of vt = $M^0L^1T^{-l} \times M^0L^0T^1 = M^0L^1T^0$

But the argument of the trigonometric function must be dimensionless, which is not so in the given case. Hence, the given formula is dimensionally incorrect.

c. Incorrect

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

Dimension of y = $M^0L^1T^0$

Dimension of $\frac{\alpha}{T} = M^0L^1T^{-1}$

Dimension of $\frac{t}{a} = M^0L^{-1}T^l$

But the argument of the trigonometric function must be dimensionless, which is not so in the given case. Hence, the formula is dimensionally incorrect.

d. Correct

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

Dimension of y = $M^0L^1T^0$

Dimension of a = $M^0L^1T^0$

Dimension of $\frac{t}{T} = M^0 I^0 T^0$

Since the argument of the trigonometric function must be dimensionless (which is true in the given case), the dimensions of y and a are the same. Hence, the given formula is dimensionally correct.

15. i. Mean Value of diameter

$D_{mean} = \frac{d_1+d_2+d_3+d_4+d_5+d_6}{6} = \frac{1.328+1.330+1.325+1.326+1.334+1.336}{6}$

$= \frac{7.979}{6}$ = 1.3298 = 1.330 cm

ii. Absolute Error in different observations are

$\Delta D_1 = D_{mean} - d_1 = 1.330 - 1.328$ = 0.002 cm

$\Delta D_2 = D_{mean} - d_2 = 1.330 - 1.330$ = 0 cm

$\Delta D_3 = D_{mean} - d_3 = 1.330 - 1.325$ = + 0.005 cm

$\Delta D_4 = D_{mean} - d_4 = 1.330 - 1.326$ = 0.004 cm

$\Delta D_5 = D_{mean} - d_5 = 1.330 - 1.334$ = - 0.004 cm

$\Delta D_6 = D_{mean} - d_6 = 1.330 - 1.336$ = - 0.006 cm

iii. Mean absolute error

$\Delta D_{\text{mean}} = \frac{|\Delta D_1|+|\Delta D_2|+|\Delta D_3|+|\Delta D_4|+|\Delta D_5|+|\Delta D_6|}{6}$

$= \frac{0.002+0+0.005+0.004+0.004+0.006}{6}$

$= \frac{0.021}{6}$ = 0.0035 = 0.004 cm

iv. Fractional Error = $\delta d = \frac{\Delta D_{\text{mean}}}{D_{\text{mean}}} = \pm \frac{0.004}{1.330}$ = ±0.003 cm

v. Percentage Error = $\delta d \times 100$ = ±0.003 $\times$ 100% = ±0.3%

vi. Diameter of wire = (1.330 ± 0.003) cm

or D = 1.330 cm ± 0.3 %