ANSWERS

Chapter 2

2.1 (b)

2.2 (b)

2.3 (c)

2.4 (d)

2.5 (a)

2.6 (c)

2.7 (a)

2.8 (d)

2.9 (a)

2.10 (a)

2.11 (c)

2.12 (d)

2.13 (b), (c)

2.14 (a), (e)

2.15 (b), (d)

2.16 (a), (b), (d)

2.17 (a), (b)

2.18 (b), (d)

2.19 Because, bodies differ in order of magnitude significantly in respect to the same physical quantity. For example, interatomic distances are of the order of angstroms, inter-city distances are of the order of km, and interstellar distances are of the order of light year.

2.20 10^{15}

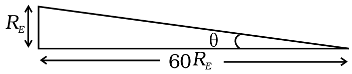
2.21 Mass spectrograph

2.22 $1 \text{ u} = 1.67 \times 10^{-27}$ kg

2.23 Since $f(\theta)$ is a sum of different powers of θ, it has to be dimensionless

2.24 Because all other quantities of mechanics can be expressed in terms of length, mass and time through simple relations.

2.25 (a) $\theta = \dfrac{R_E}{60R_E} = \dfrac{1}{60} \text{rad} \simeq 1^o$



$\therefore$ Diameter of the earth as seen from the moon is about 2°.

(b) At earth-moon distance, moon is seen as (1/2)° diameter and earth is seen as 2° diameter. Hence, diameter of earth is 4 times the diameter of moon.

$$\frac{D_{earth}}{D_{moon}} = 4$$

(c) $\dfrac{r_{sun}}{r_{moon}} = 400$

(Here r stands for distance, and D for diameter.)

Sun and moon both appear to be of the same angular diameter as seen from the earth.

$$\therefore \frac{D_{sun}}{r_{sun}} = \frac{D_{moon}}{r_{moon}}$$

$$\therefore \frac{D_{sun}}{D_{moon}} = 400$$

But $\dfrac{D_{earth}}{D_{moon}} = 4 \quad \therefore \dfrac{D_{sun}}{D_{earth}} = 100$.

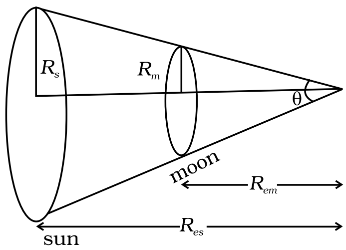
2.26 An atomic clock is the most precise time measuring device because atomic oscillations are repeated with a precision of 1s in 10^{13} s.

2.27 3×10^{16} s

2.28 0.01 mm

2.29 $\theta = \left(\pi R_s^{\,2} / R_{es}^{\,2}\right)\left(\pi R_m^{\,2} / R_{em}^{\,2}\right)$

$$\Rightarrow \frac{R_s}{R_m} = \frac{R_{es}}{R_{em}}$$



2.30 10^5 kg

2.31 (a) Angle or solid angle
(b) Relative density, etc.
(c) Planck's constant, universal gravitational constant, etc.
(d) Raynold number

2.32 $\theta = \frac{l}{r} \Rightarrow l = r\theta \Rightarrow l = 31 \times \frac{3.14}{6}\,\text{cm} = 16.3\,\text{cm}$

2.33 4×10^{-2} steradian

2.34 Dimensional formula of ω = T^{-1}
Dimensional formula of k = L^{-1}

2.35 (a) Precision is given by the least count of the instrument.

For 20 oscillations, precision = 0.1 s

For 1 oscillation, precision = 0.005 s.

(b) Average time $t = \frac{39.6 + 39.9 + 39.5}{3}\,\text{s} = 39.6\text{s}$

Period $= \frac{39.6}{20} = 1.98\,\text{s}$

Max. observed error = (1.995 –1.980)s = 0.015s.

2.36 Since energy has dimensions of ML^2T^{-2}, 1J in new units becomes $\gamma^2/\alpha\beta^2$ J. Hence 5 J becomes $5\gamma^2/\alpha\beta^2$.

2.37 The dimensional part in the expression is $\frac{\rho r^4}{\eta l}$. Therefore, the dimensions of the right hand side comes out to be $\frac{[ML^{-1}T^{-2}][L^4]}{[ML^{-1}T^{-1}][L]} = \frac{[L^3]}{[T]}$, which is volume upon time. Hence, the formula is dimensionally correct.

2.38 The fractional error in X is

$$\frac{dX}{X} = \frac{2da}{a} + \frac{3db}{b} + \frac{2.5dc}{c} + \frac{2d(d)}{d}$$

$$= 0.235 \simeq 0.24$$

Since the error is in first decimal, hence the result should be rounded off as 2.8.

2.39 Since E, l and G have dimensional formulas:

$$E \to ML^2T^{-2}$$

$$l \to ML^2T^{-1}$$

$$G \to L^3M^{-1}T^{-2}$$

Hence, P = E l^2 m^{-5} G^{-2} will have dimensions:

$$[P] = \frac{[ML^2T^{-2}][M^2L^4T^{-2}][M^2T^4]}{[M^5][L^6]}$$

$$= M^0\, L^0\, T^0$$

Thus, P is dimensionless.

2.40 M, L, T, in terms of new units become

$$M \to \sqrt{\frac{ch}{G}},\ L \to \sqrt{\frac{hG}{c^3}},\ T \to \sqrt{\frac{hG}{c^5}}$$

2.41 Given $T^2 \ \alpha \ r^3 \ \Rightarrow \ T \ \alpha \ r^{3/2}$. T is also function of g and $R \Rightarrow T \ \alpha \ g^x R^y$

$$\therefore [L^oM^oT^1] = [L^{3/2}M^oT^o][L^1M^oT^{-2}]^x\,[L^1M^oT^o]^y$$

For L, $0 = \frac{3}{2} + x + y$

For T, $1 = 0 - 2x \Rightarrow x = -\frac{1}{2}$

Therefore, $0 = \frac{3}{2} - \frac{1}{2} + y \Rightarrow y = -1$

Thus, $T = k r^{3/2} g^{-1/2} R^{-1} = \frac{k}{R}\sqrt{\frac{r^3}{g}}$

2.42 (a) Because oleic acid dissolves in alcohol but does not disssolve in water.

(b) When lycopodium powder is spread on water, it spreads on the entire surface. When a drop of the prepared solution is dropped on water, oleic acid does not dissolve in water, it spreads on the water surface pushing the lycopodium powder away to clear a circular area where the drop falls. This allows measuring the area where oleic acid spreads.

(c) $\frac{1}{20}\text{mL}\times\frac{1}{20}=\frac{1}{400}\text{mL}$

(d) By means of a burette and measuring cylinder and measuring the number of drops.

(e) If n drops of the solution make 1 mL, the volume of oleic acid in one drop will be $(1/400)n$ mL.

2.43 (a) By definition of parsec

$$\therefore\ 1\text{ parsec} = \left(\frac{1\text{A.U.}}{1\text{ arc sec}}\right)$$

1 deg = 3600 arc sec

$$\therefore\ 1\text{ arcsec} = \frac{\pi}{3600\times180}\text{ radians}$$

$$\therefore\ 1\text{ parsec} = \frac{3600\times180}{\pi}\text{ A.U.} = 206265\text{ A.U.} \approx 2\times10^5\text{ A.U.}$$

(b) At 1 A.U. distance, sun is (1/2°) in diameter.

Therefore, at 1 parsec, star is $\frac{1/2}{2\times10^5}$ degree in diameter = 15 × 10^{-5} arcmin.

With 100 magnification, it should look 15 × 10^{-3} arcmin. However, due to atmospheric fluctuations, it will still look of about 1 arcmin. It can't be magnified using telescope.

(c) $\frac{D_{mars}}{D_{earth}}=\frac{1}{2},\ \frac{D_{earth}}{D_{sun}}=\frac{1}{400}$ [from Answer 2.25 (c)]

$$\therefore\ \frac{D_{mars}}{D_{sun}}=\frac{1}{800}.$$

At 1 A.U. sun is seen as 1/2 degree in diameter, and mars will be seen as 1/1600 degree in diameter.

At 1/2 A.U, mars will be seen as 1/800 degree in diameter. With 100 magnification mars will be seen as 1/8 degree $=\frac{60}{8}=7.5$ arcmin.

This is larger than resolution limit due to atmospheric fluctuations. Hence, it looks magnified.

2.44 (a) Since 1 u = 1.67 × 10^{-27} kg, its energy equivalent is $1.67\times10^{-27}\ c^2$ in SI units. When converted to eV and MeV, it turns out to be 1 u ≡ 931.5 MeV.

(b) 1 u × c^2 = 931.5 MeV.