Answers and Solutions

Units

1. (c) Light year is a distance which light travels in one year.
2. (b) Because magnitude is absolute.
3. (d) *Watt=Joule/second* = *Ampere*×*volt* = *Ampere*^{2}×*Ohm*
4. (c) Impulse = change in momentum = $F \times t$
So the unit of momentum will be equal to *Newton-sec.*
5. (c) Unit of energy will be $kg\text{-}m^2/\sec^2$
6. (d) It is by standard definition.
7. (c) $1\ nm = 10^{-9}\ m = 10^{-7}\ cm$
8. (d) $1\ micron = 10^{-6}\ m = 10^{-4}\ cm$
9. (c) *Watt* = *Joule/sec*.
10. (c) $F = \frac{Gm_1m_2}{d^2}$; $\therefore\ G = \frac{Fd^2}{m_1m_2} = Nm^2/kg^2$
11. (a)
12. (c) Angular acceleration $= \frac{\text{Angular velocity}}{\text{Time}} = \frac{rad}{\sec^2}$
13. (c) Stefan's law is $E = \sigma(T^4) \Rightarrow \sigma = \frac{E}{T^4}$
where, $E = \frac{\text{Energy}}{\text{Area} \times \text{Time}} = \frac{\text{Watt}}{m^2}$
$\sigma = \frac{\text{Watt-}m^{-2}}{K^4} = Watt\text{-}m^{-2}K^{-4}$
14. (b) *Kg-m/sec* is the unit of linear momentum
15. (d) ct^2 must have dimensions of L
$\Rightarrow$ c must have dimensions of L/T^2 *i.e.* LT^{-2}.
16. (d) $\tau = \frac{dL}{dt} \Rightarrow dL = \tau \times dt = r \times F \times dt$
i.e. the unit of angular momentum is *joule-second.*
17. (c)
18. (a) Volume of cube = a^3
Surface area of cube = $6a^2$
according to problem $a^3 = 6a^2 \Rightarrow a = 6$
$\therefore V = a^3 = 216\ units$.
19. (b) $6 \times 10^{-5} = 60 \times 10^{-6} = 60\ microns$
20. (d)
21. (d) Because temperature is a fundamental quantity.
22. (a)
23. (a) 1 C.G.S unit of density = 1000 M.K.S. unit of density $\Rightarrow 0.5\ gm/cc = 500\ kg/m^3$
24. (b)
25. (d)
26. (b) Mach number $= \frac{\text{Velocity of object}}{\text{Velocity of sound}}$.
27. (d)
28. (d) $E = -\frac{dV}{dx}$
29. (d)
30. (b) Surface tension = $\frac{\text{Force}}{\text{Length}}$ = $Newton/metre$
31. (a)
32. (b) $L = \frac{\phi}{I} = \frac{Wb}{A} = Henry$.
33. (a) $\frac{L}{R}$ is a time constant of *L-R* circuit so *Henry/ohm* can be expressed as *second.*
34. (b) $mv = kg\left(\frac{m}{\sec}\right)$
35. (a) Quantities of similar dimensions can be added or subtracted so unit of *a* will be same as that of velocity.
36. (b) $1\ MeV = 10^6\ eV$
37. (a) Energy (E) = $F \times d \Rightarrow F = \frac{E}{d}$ so *Erg/metre* can be the unit of force.
38. (b) Potential energy $= mgh = g\left(\frac{cm}{\sec^2}\right)cm = g\left(\frac{cm}{\sec}\right)^2$
39. (b) $\frac{watt}{ampere} = volt$
40. (b)
41. (d)
42. (c)
43. (b,c)
44. (c) Energy = force × distance, so if both are increased by 4 times then energy will increase by 16 times.
45. (b) 1 Oerstead = 1 Gauss = $10^{-4}\ Tesla$
46. (a) Charge = current × time
47. (c) $R = \rho\frac{L}{A} \Rightarrow \rho = \frac{RA}{L} = ohm \times cm$
48. (c)
49. (a) Astronomical unit of distance.

50. (a) Physical quantity (p) = Numerical value (n) $\times$ Unit (u)

If physical quantity remains constant then $n \propto 1/u \therefore n_1u_1 = n_2u_2$.

51. (b) $1\, eV = 1.6 \times 10^{-19}\, coulomb \times 1\, volt = 1.6 \times 10^{-19}\, J$.

52. (b) $1\, kWh = 1 \times 10^3 \times 3600\, W \times \sec = 36 \times 10^5\, J$

53. (c) According to the definition.

54. (c)

55. (c) As $I = MR^2 = kg - m^2$

56. (c) $\text{Stress} = \frac{\text{Force}}{\text{Area}} = \frac{N}{m^2}$

57. (b) $\frac{Q}{t} = \sigma A T^4 \Rightarrow \sigma = Jm^{-2}s^{-1}K^{-4}$

58. (a) M = Pole strength $\times$ length

$= amp - metre \times metre = amp - metre^2$

59. (c) *Curie* = *disintegration*/*second*

60. (a)

61. (c) Pico prefix used for 10^{-12}

62. (c)

63. (d) Unit of $e.m.f.$ = *volt* = *joule*/*coulomb*

64. (d)

65. (b)

66. (c) $Y = \frac{F}{A} \cdot \frac{L}{\Delta L} = \frac{dyne}{cm^2} = \frac{10^{-5}\, N}{10^{-4}\, m^2} = 0.1\, N/m^2$

67. (a) $Y = \frac{\text{Stress}}{\text{Strain}} = \frac{\text{Force/Area}}{\text{Dimensionless}} \Rightarrow Y \equiv \text{Pressure}$.

68. (b) $1\ yard = 36\ inches = 36 \times 2.54\ cm = 0.9144\, m$.

69. (c) $1\,\text{fermi} = 10^{-15}\, metre$

70. (b)

71. (d)

72. (b)

73. (b)

74. (d) 1 *Newton* = 10^5 *Dyne*

75. (c) $[x] = [bt^2] \Rightarrow [b] = [x/t^2] = km/s^2$

76. (b) Units of a and PV^2 are same and equal to $dyne \times cm^4$.

77. (b)

78. (b)

79. (c) Impulse = Force $\times$ time $= (kg\text{-}m/s^2) \times s = kg\text{-}m/s$

80. (c)

81. (a) $K = C + 273.15$

82. (a)

83. (d)

84. (c)

85. (b)

86. (d) *Watt* is a unit of power

87. (d) $1\,\text{light year} = 9.46 \times 10^{15}\ meter$

88. (b) $V = \frac{W}{m}$ so, SI unit = $\frac{Joule}{kg}$

89. (a)

90. (c) $n_2 = n_1\left(\frac{M_1}{M_2}\right)^1\left(\frac{L_1}{L_2}\right)^1\left(\frac{T}{T_2}\right)^{-2}$

$= 100\left(\frac{gm}{kg}\right)^1\left(\frac{cm}{m}\right)^1\left(\frac{\sec}{min}\right)^{-2}$

$= 100\left(\frac{gm}{10^3\, gm}\right)^1\left(\frac{cm}{10^2\, cm}\right)^1\left(\frac{\sec}{60\sec}\right)^{-2}$

$n_2 = \frac{3600}{10^3} = 3.6$

91. (a) $[L/R]$ is a time constant so its unit is *Second*.

92. (d) Poission ratio is a unitless quantity.

93. (b)

94. (a)

95. (d) $P = nu \therefore n \propto \frac{1}{u}$

96. (a) 1 *Faraday* = 96500 *coulomb*.

97. (b)

98. (a)

99. (d)

100. (b)

101. (d) $F = \frac{1}{4\pi \in} \frac{q_1q_2}{r^2} \Rightarrow \in = \frac{1}{4\pi} \frac{q_1q_2}{Fr^2} = C^2m^{-2}N^{-1}$

102. (d) *Joule-sec* is the unit of angular momentum where as other units are of energy.

103. (a) $T = \frac{F}{l} = Nm^{-1}$

104. (a) Because in S.I. system there are seven fundamental quantities.

105. (d) $[\eta] = ML^{-1}T^{-1}$ so its unit will be *kg/m-sec*.

106. (b)

107. (b)

108. (b) According to the definition.

109. (b) Pyrometer is used for measurement of temperature.

Dimensions

1. (a) Pressure $= \frac{\text{Force}}{\text{Area}} = ML^{-1}T^{-2}$

Stress $= \frac{\text{Restoring force}}{\text{Area}} = ML^{-1}T^{-2}$

2. (c) Strain $=\frac{\Delta L}{L}\Rightarrow$ dimensionless quantity

3. (b) Power $=\frac{\text{Work}}{\text{Time}}=\frac{ML^2T^{-2}}{T}=ML^2T^{-3}$

4. (a) *Calorie* is the unit of heat *i.e.*, energy.
So dimensions of energy $=ML^2T^{-2}$

5. (b) Angular momentum $= mvr = MLT^{-1}\times L = ML^2T^{-1}$

6. (c) $\frac{L}{R}$ = Time constant

7. (c) Impulse = change in momentum so dimensions of both quantities will be same and equal to MLT^{-1}

8. (b) $RC = T$
$\because [R]=[ML^2T^{-3}I^{-2}]$ and $[C]=[M^{-1}L^{-2}T^4I^2]$

9. (a,d) [Torque] = [work] = $[ML^2T^{-2}]$
[Light year] = [Wavelength] = $[L]$

10. (a) $Q = mL \Rightarrow L=\frac{Q}{m}$ (Heat is a form of energy)
$=\frac{ML^2T^{-2}}{M}=[M^0L^2T^{-2}]$

11. (d) Volume elasticity = $\frac{\text{Force/Area}}{\text{Volume strain}}$
Strain is dimensionless, so
$=\frac{\text{Force}}{\text{Area}}=\frac{MLT^{-2}}{L^2}=[ML^{-1}T^{-2}]$

12. (b) $F=\frac{Gm_1m_2}{d^2}\Rightarrow G=\frac{Fd^2}{m_1m_2}$
$\therefore [G]=\frac{[MLT^{-2}][L^2]}{[M^2]}=[M^{-1}L^3T^{-2}]$

13. (a) Angular velocity = $\frac{\theta}{t}$, $[\omega]=\frac{[M^0L^0T^0]}{[T]}=[T^{-1}]$

14. (a) Power = $\frac{\text{Work done}}{\text{Time}}=\left[\frac{ML^2T^{-2}}{T}\right]=[ML^2T^{-3}]$

15. (a) Couple = Force × Arm length = $[MLT^{-2}][L]=[ML^2T^{-2}]$

16. (b) Angular momentum = mvr
$=[MLT^{-1}][L]=[ML^2T^{-1}]$

17. (b) Impulse = Force × Time = $[MLT^{-2}][T]=[MLT^{-1}]$

18. (d) Modulus of rigidity = $\frac{\text{Shear stress}}{\text{Shear strain}}=[ML^{-1}T^{-2}]$

19. (a)

20. (c) $E=h\nu\Rightarrow[ML^2T^{-2}]=[h][T^{-1}]\Rightarrow[h]=[ML^2T^{-1}]$

21. (b) Moment of inertia $= mr^2=[M][L^2]$
Moment of Force = Force × Perpendicular distance
$=[MLT^{-2}][L]=[ML^2T^{-2}]$

22. (a) Momentum = $mv=[MLT^{-1}]$
Impulse = Force × Time = $[MLT^{-2}]\times[T]=[MLT^{-1}]$

23. (b) Pressure = $\frac{\text{Force}}{\text{Area}}=\frac{\text{Energy}}{\text{Volume}}=ML^{-1}T^{-2}$

24. (d) $[h]=[\text{Angular momentum}]=[ML^2T^{-1}]$

25. (a) By principle of dimensional homogenity
$\left[\frac{a}{V^2}\right]=[P]$
$\therefore [a]=[P][V^2]=[ML^{-1}T^{-2}]\times[L^6]=[ML^5T^{-2}]$

26. (d) $\frac{1}{2}CV^2$ = Stored energy in a capacitor = $[ML^2T^{-2}]$

27. (a) $\frac{1}{2}Li^2$ = Stored energy in an inductor = $[ML^2T^{-2}]$

28. (d) Energy per unit volume = $\frac{[ML^2T^{-2}]}{[L^3]}=[ML^{-1}T^{-2}]$
Force per unit area = $\frac{[MLT^{-2}]}{[L^2]}=[ML^{-1}T^{-2}]$
Product of voltage and charge per unit volume
$=\frac{V\times Q}{\text{Volume}}=\frac{VIt}{\text{Volume}}=\frac{\text{Power}\times\text{Time}}{\text{Volume}}$
$\Rightarrow \frac{[ML^2T^{-3}][T]}{[L^3]}=[ML^{-1}T^{-2}]$
Angular momentum per unit mass = $\frac{[ML^2T^{-1}]}{[M]}=[L^2T^{-1}]$
So angular momentum per unit mass has different dimension.

29. (d) Time constant $\tau=[T]$ and Viscosity $\eta=[ML^{-1}T^{-1}]$
For options (a), (b) and (c) dimensions are not matching with time constant.

30. (d) By putting the dimensions of each quantity both the sides we get $[T^{-1}]=[M]^x[MT^{-2}]^y$
Now comparing the dimensions of quantities in both sides we get
$x+y=0$ and $2y=1$ $\therefore$ $x=-\frac{1}{2}, y=\frac{1}{2}$

31. (c) m = linear density = mass per unit length = $\left[\frac{M}{L}\right]$

A= force $=[MLT^{-2}]$ ∴ $[B]=\frac{[A]}{[m]}=\frac{[MLT^{-2}]}{[ML^{-1}]}$ $=[L^2T^{-2}]$

This is same dimension as that of latent heat.

32. (c) Let $v^x = kg^y\lambda^z\rho^\delta$. Now by substituting the dimensions of each quantities and equating the powers of M, L and T we get $\delta=0$ and $x=2, y=1, z=1$.

33. (a) *Farad* is the unit of capacitance and $C=\frac{Q}{V}=$ $\frac{[Q]}{[ML^2T^{-2}Q^{-1}]}=M^{-1}L^{-2}T^2Q^2$

34. (a) $\rho=\frac{RA}{l}$ *i.e.* dimension of resistivity is $[ML^3T^{-1}Q^{-2}]$

35. (b) From the principle of homogenity $\left(\frac{x}{v}\right)$ has dimensions of T.

36. (b) $\frac{dQ}{dt}=-KA\left(\frac{d\theta}{dx}\right)$

$\Rightarrow [K]=\frac{[ML^2T^{-2}]}{[T]}\times\frac{[L]}{[L^2][K]}=MLT^{-3}K^{-1}$

37. (c) Stress = $\frac{\text{Force}}{\text{Area}}=\frac{[MLT^{-2}]}{[L^2]}=[ML^{-1}T^{-2}]$

38. (c)

39. (a) $[C]=\left(\frac{Q}{V}\right)=\left(\frac{Q^2}{W}\right)=\left[\frac{A^2T^2}{ML^2T^{-2}}\right]=[M^{-1}L^{-2}T^4A^2]$

40. (b) Momentum = mv = $[MLT^{-1}]$

41. (a) $Q=[ML^2T^{-2}]$ (All energies have same dimension)

42. (b) $f=\frac{1}{2\pi\sqrt{LC}}\Rightarrow LC=\frac{1}{f^2}=[M^0L^0T^2]$

43. (d) Energy = Work done [Dimensionally]

44. (d) $\frac{L}{R}=$ Time constant.

45. (a) By substituting the dimension of each quantity we get $T=[ML^{-1}T^{-2}]^a[L^{-3}M]^b[MT^{-2}]^c$

By solving we get a = – 3/2, b = 1/2 and c = 1

46. (d)

47. (b) $v\propto g^p h^q$ (given)

By substituting the dimension of each quantity and comparing the powers in both sides we get $[LT^{-1}]=[LT^{-2}]^p[L]^q$

$\Rightarrow p+q=1, -2p=-1, \therefore p=\frac{1}{2}, q=\frac{1}{2}$

48. (d) [Planck constant] = $[ML^2T^{-1}]$ and [Energy] = $[ML^2T^{-2}]$

49. (b) Frequency $=\frac{1}{T}=[M^0L^0T^{-1}]$

50. (a) Power = $\frac{\text{Energy}}{\text{Time}}$

51. (a) By substituting dimension of each quantity in R.H.S. of option (a) we get $\left[\frac{mg}{\eta r}\right]=\left[\frac{M\times LT^{-2}}{ML^{-1}T^{-1}\times L}\right]=[LT^{-1}]$.

This option gives the dimension of velocity.

52. (d) $[\varepsilon_0 L]$ = [C] ∴ $X=\frac{\varepsilon_0 LV}{t}=\frac{C\times V}{t}=\frac{Q}{t}=$ current

53. (b) $C=\frac{1}{\sqrt{\mu_0\varepsilon_0}}\Rightarrow\mu_0\varepsilon_0=\left(\frac{1}{C^2}\right)$(where C = velocity of light)

∴ $[\mu_0\varepsilon_0]=L^{-2}T^2$

54. (b)

55. (c) $[X]=[F]\times[\rho]=[MLT^{-2}]\times\left[\frac{M}{L^3}\right]=[M^2L^{-2}T^{-2}]$

56. (c) Both are the formula of energy . $\left(E=\frac{1}{2}CV^2=\frac{1}{2}LI^2\right)$

57. (d) Acceleration = $\frac{\text{distance}}{\text{time}^2}\Rightarrow A=LT^{-2}\Rightarrow L=AT^2$

58. (a) $\frac{1}{\sqrt{\varepsilon_0\mu_0}}=C=$ velocity of light

59. (a) According to problem muscle × speed = power

∴ muscle = $\frac{\text{power}}{\text{speed}}=\frac{ML^2T^{-3}}{LT^{-1}}=MLT^{-2}$

60. (c)

61. (b) Wave number = $\frac{1}{\lambda}$ ∴ dimension is $[M^0L^{-1}T^0]$

62. (b) [Pressure] =[stress] = $[ML^{-1}T^{-2}]$

63. (c)

64. (a) $F=\frac{\mu_0}{4\pi}\frac{2I_1I_2l}{r}$ ⇒ $\mu_0=[F][A]^{-2}=[MLT^{-2}A^{-2}]$

65. (a) $\phi=BA=\frac{F}{I\times L}A=\frac{[MLT^{-2}][L^2]}{[A][L]}=[ML^2T^{-2}A^{-1}]$

66. (b) By substituting the dimension of given quantities $[ML^{-1}T^{-2}]^x[MT^{-3}]^y[LT^{-1}]^z = [MLT]^0$

By comparing the power of *M, L, T* in both sides $x+y=0$ .....(i)

$-x+z=0$ .....(ii)

$-2x-3y-z=0$ …(iii)

The only values of x, y, z satisfying (i), (ii) and (iii) corresponds to (b).

67. (a) $E=\frac{1}{2}Li^2$ hence $L=[ML^2T^{-2}A^{-2}]$

68. (d) Strain is dimensionless.

69. (c) Dimensions of power is $[ML^2T^{-3}]$

70. (a) Kinetic energy = $\frac{1}{2}mv^2 = M[LT^{-1}]^2 = [ML^2T^{-2}]$

71. (a) Torque = force × distance = $[ML^2T^{-2}]$

72. (c) $F=-\eta . A\frac{dv}{dx} \Rightarrow [\eta]=[ML^{-1}T^{-1}]$

73. (c) $\frac{L}{RCV}=\left[\frac{L}{R}\right]\frac{1}{CV}=\frac{T}{Q}=[A^{-1}]$

74. (a) $\frac{\text{Angular momentum}}{\text{Linear momentum}}=\frac{mvr}{mv}=r=[M^0L^1T^0]$

75. (b) Dimension of work and torque = $[ML^2T^{-2}]$

76. (d) Surface tension = $\frac{\text{Force}}{\text{Length}}=\frac{[MLT^{-2}]}{L}=[MT^{-2}]$

77. (a) Linear momentum = Mass × Velocity = $[MLT^{-1}]$

Moment of a force = Force × Distance = $[ML^2T^{-2}]$

78. (a) $\frac{R}{L}=\frac{V/I}{V\times T/I}=\frac{1}{T}=$ Frequency

79. (b) $L\propto v^xA^yF^z \Rightarrow L=kv^xA^yF^z$

Putting the dimensions in the above relation

$[ML^2T^{-1}]=k[LT^{-1}]^x[LT^{-2}]^y[MLT^{-2}]^z$

$\Rightarrow [ML^2T^{-1}]=k[M^zL^{x+y+z}T^{-x-2y-2z}]$

Comparing the powers of M, L and T

$z=1$ …(i)

$x+y+z=2$ …(ii)

$-x-2y-2z=-1$ …(iii)

On solving (i), (ii) and (iii) $x=3, y=-2, z=1$

So dimension of L in terms of v, A and f

$[L]=[Fv^3A^{-2}]$

80. (b) $F=\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}$

$\Rightarrow \varepsilon_0=\frac{|q_1||q_2|}{[F][r^2]}=\frac{[A^2T^2]}{[MLT^{-2}][L^2]}=[A^2T^4M^{-1}L^{-3}]$

81. (d) [Pressure] = [Stress] = [coefficient of elasticity] = $[ML^{-1}T^{-2}]$

82. (b)

83. (b, c)

84. (c) Capacity × Resistance = $\frac{\text{Charge}}{\text{Potential}}\times\frac{\text{Volt}}{\text{amp}}$

$=\frac{\text{amp}\times\text{second}\times\text{Volt}}{\text{Volt}\times\text{amp}}=\text{Second}$

85. (d) Strain has no dimensions.

86. (d)

87. (c) $B=\frac{F}{IL}=\frac{[MLT^{-2}]}{[A][L]}=[MT^{-2}A^{-1}]$

88. (a) $\eta=\frac{F}{av}=\frac{[MLT^{-2}]}{[L][LT^{-1}]}=[ML^{-1}T^{-1}]$

89. (a) Couple of force = $|\vec{r}\times\vec{F}|=[ML^2T^{-2}]$

Work = $[\vec{F}.\vec{d}]=[ML^2T^{-2}]$

90. (a) Quantities having different dimensions can only be divided or multiplied but they cannot be added or subtracted.

91. (a) Angle of banking : $\tan\theta=\frac{v^2}{rg}$. *i.e.* $\frac{v^2}{rg}$ is dimensionless.

92. (b) Solar constant is energy received per unit area per unit time *i.e.* $\frac{[ML^2T^{-2}]}{[L^2][T]}=[M^1T^{-3}]$

93. (b) From the principle of dimensional homogenity $[a]=\left[\frac{F}{t}\right]=[MLT^{-3}]$ and $[b]=\left[\frac{F}{t^2}\right]=[MLT^{-4}]$

94. (a) $K=Y\times r_0=[ML^{-1}T^{-2}]\times[L]=[MT^{-2}]$

$Y=$ Young's modulus and r_0 = Interatomic distance

95. (b) Let $[G]\propto c^xg^yp^z$

by substituting the following dimensions :

$[G]=[M^{-1}L^3T^{-2}], [c]=[LT^{-1}], [g]=[LT^{-2}]$

$[p]=[ML^{-1}T^{-2}]$

and by comparing the powers of both sides we can get $x=0, y=2, z=-1$

$\therefore [G]\propto c^0g^2p^{-1}$

96. (a) Let $T\propto S^xr^y\rho^z$

by substituting the dimension of $[T]=[T]$

$[S]=[MT^{-2}], [r]=[L], [\rho]=[ML^{-3}]$

and by comparing the power of both the sides

$x = -1/2, y = 3/2, z = 1/2$

so $T \propto \sqrt{\rho r^3 / S} \Rightarrow T = k\sqrt{\frac{\rho r^3}{S}}$

97. (a) Resistivity $[\rho] = \frac{[R].[A]}{[l]}$ where $[R] = [ML^2T^{-1}Q^{-2}]$

$\therefore [\rho] = [ML^3T^{-1}Q^{-2}]$

98. (a) $I = \frac{Q}{t} = \frac{[Q]}{[T]} = [M^0L^0T^{-1}Q]$

99. (c) Torque = $[ML^2T^{-2}]$, Angular momentum = $[ML^2T^{-1}]$ So mass and length have the same dimensions

100. (a) Let $F \propto P^xV^yT^z$

by substituting the following dimensions :

$[P] = [ML^{-1}T^{-2}]$ $[V] = [LT^{-1}], [T] = [T]$

and comparing the dimension of both sides

$x = 1, y = 2, z = 2$, so $F = PV^2T^2$

101. (d) $\frac{\text{Energy}}{\text{mass} \times \text{length}} = \frac{[ML^2T^{-2}]}{[M][L]} = [LT^{-2}]$

102. (b) Let $m \propto E^xv^yF^z$

By substituting the following dimensions :

$[E] = [ML^2T^{-2}], [v] = [LT^{-1}], [F] = [MLT^{-2}]$

and by equating the both sides

$x = 1, y = -2, z = 0$. So $[m] = [Ev^{-2}]$

103. (b)

104. (d) $x = Ay + B\tan Cz$

From the dimensional homogenity

$[x] = [Ay] = [B] \Rightarrow \left[\frac{x}{A}\right] = [y] = \left[\frac{B}{A}\right]$

$[Cz] = [M^0L^0T^0] =$ Dimension less

x and B; C and Z^{-1}; y and $\frac{B}{A}$ have the same dimension but x and A have the different dimensions.

105. (c) Tension = $[MLT^{-2}]$, Surface Tension = $[MT^{-2}]$

106. (d) Torque = $[ML^2T^{-2}]$, Moment of inertia = $[ML^2]$

107. (c) Angular momentum = $[ML^2T^{-1}]$, Frequency = $[T^{-1}]$

108. (c) Latent Heat $L = \frac{Q}{m} = \frac{\text{Energy}}{\text{mass}} = \frac{[ML^2T^{-2}]}{[M]} = [L^2T^{-2}]$

109. (a) $C = \frac{Q}{V} = \frac{[AT]}{[ML^2T^{-3}A^{-1}]} = [M^{-1}L^{-2}T^4A^2]$

110. (b) $C^2LR = [C^2L^2] \times \left[\frac{R}{L}\right] = [T^4] \times \left[\frac{1}{T}\right] = [T^3]$

As $\left[\frac{L}{R}\right] = T$ and $\sqrt{LC} = T$

111. (c) Let $m \propto C^xG^yh^z$

By substituting the following dimensions :

$[C] = LT^{-1}; [G] = [M^{-1}L^3T^{-2}]$ and $[h] = [ML^2T^{-1}]$

Now comparing both sides we will get

$x = 1/2; y = -1/2, z = +1/2$

So $m \propto c^{1/2}G^{-1/2}h^{1/2}$

112. (d) Charge = Current × Time = $[AT]$

113. (b) $F = -\eta A\frac{\Delta v}{\Delta z} \Rightarrow [\eta] = [ML^{-1}T^{-1}]$

As $F = [MLT^{-2}]$, $A = [L^2], \frac{\Delta v}{\Delta z} = [T^{-1}]$

114. (a)

115. (b) $\frac{\text{Energy}}{\text{Volume}} = \frac{ML^2T^{-2}}{L^3} = [ML^{-1}T^{-2}] =$ Pressure

116. (c) $\omega = \frac{d\theta}{dt} = [T^{-1}]$ and frequency $[n] = [T^{-1}]$

117. (d) $F \propto v \Rightarrow F = kv \Rightarrow [k] = \left[\frac{F}{v}\right] = \left[\frac{MLT^{-2}}{LT^{-1}}\right] = [MT^{-1}]$

118. (d) $e = L\frac{di}{dt} \Rightarrow [e] = [ML^2T^{-2}A^{-2}]\left[\frac{A}{T}\right]$

$[e] = \left[\frac{ML^2T^{-2}}{AT}\right] = [ML^2T^{-2}Q^{-1}]$

119. (d) $[G] = [M^{-1}L^3T^{-2}]; [h] = [ML^2T^{-1}]$

Power = $\frac{1}{\text{focal length}} = [L^{-1}]$

All quantities have dimensions

120. (a) $k = \left[\frac{R}{N}\right] = [ML^2T^{-2}\theta^{-1}]$

121. (a) $W = \frac{1}{2}kx^2 \Rightarrow [k] = \frac{[W]}{[x^2]} = \left[\frac{ML^2T^{-2}}{L^2}\right] = [MT^{-2}]$

122. (c) Momentum $[MLT^{-1}]$, Planck's constant $[ML^2T^{-1}]$

123. (b) $R = \frac{V}{I} = \left[\frac{ML^2T^{-3}A^{-1}}{A}\right] = [ML^2T^{-3}A^{-2}]$

124. (d) Relative density $= \frac{\text{Density of substance}}{\text{density of water}}$

$= [M^0L^0T^0]$

125. (a)

126. (a) Let $n = k\rho^a a^b T^c$ where $[\rho] = [ML^{-3}], [a] = [L]$ and $[T] = [MT^{-2}]$

Comparing both sides, we get

$a = \frac{1}{2}, b = \frac{3}{2}$ and $c = \frac{-1}{2}$ $\therefore$ $\eta = \frac{k\rho^{1/2}a^{3/2}}{\sqrt{T}}$

127. (a) $V=\frac{W}{Q}=[ML^2T^{-2}Q^{-1}]$

128. (b)

129. (c) L/R is a time constant so $(R/L)=T^{-1}$

130. (c) Shear modulus = $\frac{\text{Shearingstress}}{\text{Shearingstrain}}$ $=\frac{F}{A\theta}=[ML^{-1}T^{-2}]$

131. (d) Velocity gradient $=\frac{v}{x}=\frac{[LT^{-1}]}{[L]}=[T^{-1}]$

Potential gradient $=\frac{V}{x}=\frac{[ML^2T^{-3}A^{-1}]}{[L]}$ $=[MLT^{-3}A^{-1}]$

Energy gradient $=\frac{E}{x}=\frac{[ML^2T^2]}{[L]}=[MLT^{-2}]$

and pressure gradient $=\frac{P}{x}=\frac{[ML^{-1}T^{-2}]}{[L]}=[ML^{-2}T^{-2}]$

132. (a) Let $m=KF^aL^bT^c$

Substituting the dimension of

$[F]=[MLT^{-2}],\ [C]=[L]\ and [T]=[T]$

and comparing both sides, we get $m=FL^{-1}T^{-2}$

133. (a) $\because R=\frac{PV}{T}=\left[\frac{ML^{-1}T^{-2}\times L^3}{\theta}\right]=[ML^2T^{-2}\theta^{-1}]$

134. (c) $[Kx]=$ Dimension of $\omega t=$(dimensionless)

hence $K=\frac{1}{X}=\frac{1}{L}=\left[L^{-1}\right]$ $\therefore [K]=[L^{-1}]$

135. (b) As $x=Ka^m\times t^n$

$\left[M^0LT^0\right]=\left[LT^{-2}\right]^m[T]^n=\left[L^mT^{-2m+n}\right]$

$\therefore m=1$ and $-2m+n=0\Rightarrow n=2$.

136. (d) $NSm^{-2}=Nm^{-2}\times S=$ Pascal-second.

137. (b) $E=KF^aA^bT^c$

$\left[ML^2T^{-2}\right]=\left[MLT^{-2}\right]^a\left[LT^{-2}\right]^b[T]^c$

$\left[ML^2T^{-2}\right]=\left[M^aL^{a+b}T^{-2a-2b+c}\right]$

$\therefore a=1,\ a+b=2\Rightarrow b=1$

and $-2a-2b+c=-2\Rightarrow c=2$

$\therefore E=KFAT^2$.

138. (a)

139. (a) $\frac{h}{I}=\left[\frac{ML^2T^{-1}}{ML^2}\right]=\left[T^{-1}\right]$

140. (d)

141. (d)

142. (d) CGS SI

$N_1U_1=N_2U_2$

$N_1\left[M_1L_1^{-3}\right]=N_2\left[M_2L_2^{-3}\right]$

$\therefore N_2=N_1\left[\frac{M_1}{M_2}\right]\times\left[\frac{L_1}{L_2}\right]^{-3}=0.625\left[\frac{1g}{1kg}\right]\times\left[\frac{1cm}{1m}\right]^{-3}$

$=0.625\times10^{-3}\times10^6=625$

Errors of Measurement

1. (c) $T=2\pi\sqrt{l/g}\Rightarrow T^2=4\pi^2 l/g\Rightarrow g=\frac{4\pi^2 l}{T^2}$

Here % error in l = $\frac{1mm}{100cm}\times100=\frac{0.1}{100}\times100=0.1\%$ and % error in T = $\frac{0.1}{2\times100}\times100=0.05\%$

$\therefore$ % error in g = % error in l + 2(% error in T)

$=0.1+2\times0.05=0.2\ \%$

2. (b) $\therefore E=\frac{1}{2}mv^2$

$\therefore$% Error in K.E.

= % error in mass + 2 × % error in velocity

= 2 + 2 × 3 = 8 %

3. (b)

4. (b) Number of significant figures are 3, because 10^3 is decimal multiplier.

5. (b) $\because V=\frac{4}{3}\pi r^3$

$\therefore$ % error is volume $=3\times\%$ error in radius

$=3\times1=3\%$

6. (c) Mean time period T = 2.00 *sec*

& Mean absolute error $=\Delta T=0.05$ *sec.*

To express maximum estimate of error, the time period should be written as (2.00 ± 0.05) *sec*

7. (b) Here, $S=(13.8\pm0.2)\,m$

and $t=(4.0\pm0.3)$ *sec*

Expressing it in percentage error, we have,

$S=13.8\pm\frac{0.2}{13.8}\times100\%=13.8\pm1.4\%$

and $t=4.0\pm\frac{0.3}{4}\times100\%=4\pm7.5\%$

$\because V=\frac{s}{t}=\frac{13.8\pm1.4}{4\pm7.5}=(3.45\pm0.3)\ m/s$

8. (c) % error in velocity = %error in L + %error in t

$=\frac{0.2}{13.8}\times100+\frac{0.3}{4}\times100$

$= 1.44 + 7.5 = 8.94\ \%$

9. (c)

10. (a) $\frac{1}{20} = 0.05$

$\therefore$ Decimal equivalent upto 3 significant figures is 0.0500

11. (b)

12. (b) $\because V = \frac{4}{3}\pi r^3$

$\therefore$ % error in volume

$= 3 \times \%$ error in radius.

$= \frac{3 \times 0.1}{5.3} \times 100$

13. (a) Since percentage increase in length = 2 %

Hence, percentage increase in area of square sheet

$= 2 \times 2\% = 4\%$

14. (c) Since for 50.14 *cm*, significant number = 4 and for 0.00025, significant numbers = 2

15. (d) $a = b^\alpha c^\beta / d^\gamma e^\delta$

So maximum error in *a* is given by

$$\left(\frac{\Delta a}{a} \times 100\right)_{\max} = \alpha . \frac{\Delta b}{b} \times 100 + \beta . \frac{\Delta c}{c} \times 100 + \gamma . \frac{\Delta d}{d} \times 100 + \delta . \frac{\Delta e}{e} \times 100$$

$= (\alpha b_1 + \beta c_1 + \gamma d_1 + \delta e_1)\%$

16. (a) Weight in air $= (5.00 \pm 0.05)\ N$

Weight in water $= (4.00 \pm 0.05)\ N$

Loss of weight in water $= (1.00 \pm 0.1)\ N$

Now relative density $= \frac{\text{weight in air}}{\text{weight loss in water}}$

i.e. $R . D = \frac{5.00 \pm 0.05}{1.00 \pm 0.1}$

Now relative density with max permissible error

$= \frac{5.00}{1.00} \pm \left(\frac{0.05}{5.00} + \frac{0.1}{1.00}\right) \times 100 = 5.0 \pm (1 + 10)\%$

$= 5.0 \pm 11\%$

17. (b) $\therefore \left(\frac{\Delta R}{R} \times 100\right)_{\max} = \frac{\Delta V}{V} \times 100 + \frac{\Delta I}{I} \times 100$

$= \frac{5}{100} \times 100 + \frac{0.2}{10} \times 100 = (5 + 2)\% = 7\%$

18. (b) Average value $= \frac{2.63 + 2.56 + 2.42 + 2.71 + 2.80}{5}$

$= 2.62\ \text{sec}$

Now $|\Delta T_1| = 2.63 - 2.62 = 0.01$

$|\Delta T_2| = 2.62 - 2.56 = 0.06$

$|\Delta T_3| = 2.62 - 2.42 = 0.20$

$|\Delta T_4| = 2.71 - 2.62 = 0.09$

$|\Delta T_5| = 2.80 - 2.62 = 0.18$

Mean absolute error

$\Delta T = \frac{|\Delta T_1| + |\Delta T_2| + |\Delta T_3| + |\Delta T_4| + |\Delta T_5|}{5}$

$= \frac{0.54}{5} = 0.108 = 0.11\ sec$

19. (c) Volume of cylinder $V = \pi r^2 l$

Percentage error in volume

$\frac{\Delta V}{V} \times 100 = \frac{2\Delta r}{r} \times 100 + \frac{\Delta l}{l} \times 100$

$= \left(2 \times \frac{0.01}{2.0} \times 100 + \frac{0.1}{5.0} \times 100\right) = (1 + 2)\% = 3\%$

20. (c) $Y = \frac{4MgL}{\pi D^2 l}$ so maximum permissible error in

$Y = \frac{\Delta Y}{Y} \times 100 = \left(\frac{\Delta M}{M} + \frac{\Delta g}{g} + \frac{\Delta L}{L} + \frac{2\Delta D}{D} + \frac{\Delta l}{l}\right) \times 100$

$= \left(\frac{1}{300} + \frac{1}{981} + \frac{1}{2820} + 2 \times \frac{1}{41} + \frac{1}{87}\right) \times 100$

$= 0.065 \times 100 = 6.5\%$

21. (b) $H = I^2 Rt$

$\therefore \frac{\Delta H}{H} \times 100 = \left(\frac{2\Delta I}{I} + \frac{\Delta R}{R} + \frac{\Delta t}{t}\right) \times 100$

$= (2 \times 3 + 4 + 6)\% = 16\%$

22. (d) Kinetic energy $E = \frac{1}{2}mv^2$

$\therefore \frac{\Delta E}{E} \times 100 = \frac{v'^2 - v^2}{v^2} \times 100$

$= [(1.5)^2 - 1] \times 100$

$\therefore \frac{\Delta E}{E} \times 100 = 125\%$

23. (c) Quantity *C* has maximum power. So it brings maximum error in *P*.

24. (c) Given, $L = 2.331\ cm$

$= 2.33$ (correct upto two decimal places)

and $B = 2.1\ cm = 2.10\ cm$

$\therefore L + B = 2.33 + 2.10 = 4.43\ cm. = 4.4\ cm$

Since minimum significant figure is 2.

25. (d) The number of significant figures in all of the given number is 4.

26. (c)

27. (a) Percentage error in *X* $= a\alpha + b\beta + c\gamma$

28. (d) Percentage error in *A*

$= \left(2 \times 1 + 3 \times 3 + 1 \times 2 + \frac{1}{2} \times 2\right)\% = 14\%$

Critical Thinking Questions

1. (d) $n_2 = n_1\left[\frac{L_1}{L_2}\right]^1\left[\frac{T_1}{T_2}\right]^{-2} = 10\left[\frac{meter}{km}\right]^1\left[\frac{\sec}{hr}\right]^{-2}$

$n_2 = 10\left[\frac{m}{10^3 m}\right]^1\left[\frac{\sec}{3600\sec}\right]^{-2} = 129600$

2. (d) $f = \frac{1}{2\pi\sqrt{LC}}$ $\therefore$ $\left(\frac{C}{L}\right)$ does not represent the dimension of frequency

3. (d) $[n]$ = Number of particles crossing a unit area in unit time = $[L^{-2}T^{-1}]$

$[n_2] = [n_1]$ = number of particles per unit volume = $[L^{-3}]$

$[x_2] = [x_1]$ = positions

$\therefore\ D = \frac{[n][x_2 - x_1]}{[n_2 - n_1]} = \frac{[L^{-2}T^{-1}]\times[L]}{[L^{-3}]} = [L^2T^{-1}]$

4. (c) We can derive this equation from equations of motion so it is numerically correct.

S_t = distance travelled in t^{th} second = $\frac{\text{Distance}}{\text{time}} = [LT^{-1}]$

u = velocity = $[LT^{-1}]$ and $\frac{1}{2}a(2t-1) = [LT^{-1}]$

As dimensions of each term in the given equation are same, hence equation is dimensionally correct also.

5. (b, d) Length $\propto G^x c^y h^z$

$L = [M^{-1}L^3T^{-2}]^x\ [LT^{-1}]^y[ML^2T^{-1}]^z$

By comparing the power of M, L and T in both sides we get $-x+z=0$, $3x+y+2z=1$ and $-2x-y-z=0$

By solving above three equations we get

$x = \frac{1}{2}, y = -\frac{3}{2}, z = \frac{1}{2}$

6. (d) By substituting the dimensions of mass [M], length [L] and coefficient of rigidity $[ML^{-1}T^{-2}]$ we get $T = 2\pi\sqrt{\frac{M}{\eta L}}$ is the right formula for time period of oscillations

7. (a, b, c) Reynolds number and coefficient of friction are dimensionless.

Latent heat and gravitational potential both have dimension $[L^2T^{-2}]$.

Curie and frequency of a light wave both have dimension $[T^{-1}]$. But dimensions of Planck's constant is $[ML^2T^{-1}]$ and torque is $[ML^2T^{-2}]$

8. (a) Time $\propto c^x G^y h^z \Rightarrow T = kc^x G^y h^z$

Putting the dimensions in the above relation

$\Rightarrow\ [M^0L^0T^1] = [LT^{-1}]^x[M^{-1}L^3T^{-2}]^y[ML^2T^{-1}]^z$

$\Rightarrow\ [M^0L^0T^1] = [M^{-y+z}L^{x+3y+2z}T^{-x-2y-z}]$

Comparing the powers of M, L and T

$-y+z=0$ …(i)

$x+3y+2z=0$ …(ii)

$-x-2y-z=1$ …(iii)

On solving equations (i) and (ii) and (iii)

$x = \frac{-5}{2}, y = z = \frac{1}{2}$

Hence dimension of time are $[G^{1/2}h^{1/2}c^{-5/2}]$

9. (a) Let radius of gyration $[k] \propto [h]^x[c]^y[G]^z$

By substituting the dimension of $[k] = [L]$

$[h] = [ML^2T^{-1}], [c] = [LT^{-1}], [G] = [M^{-1}L^3T^{-2}]$

and by comparing the power of both sides we can get $x = 1/2, y = -3/2, z = 1/2$

So dimension of radius of gyration are $[h]^{1/2}[c]^{-3/2}[G]^{1/2}$

10. (d) $Y = \frac{X}{3Z^2} = \frac{M^{-1}L^{-2}T^4A^2}{[MT^{-2}A^{-1}]^2} = [M^{-3}L^{-2}T^8A^4]$

11. (a) In given equation, $\frac{\alpha z}{k\theta}$ should be dimensionless

$\therefore\ \alpha = \frac{k\theta}{z} \Rightarrow [\alpha] = \frac{[ML^2T^{-2}K^{-1}\times K]}{[L]} = [MLT^{-2}]$

and $P = \frac{\alpha}{\beta} \Rightarrow [\beta] = \left[\frac{\alpha}{p}\right] = \frac{[MLT^{-2}]}{[ML^{-1}T^{-2}]} = [M^0L^2T^0]$.

12. (c) $v = \frac{P}{2l}\left[\frac{F}{m}\right]^{1/2} \Rightarrow v^2 = \frac{P^2}{4l^2}\left[\frac{F}{m}\right] \therefore m \propto \frac{F}{l^2v^2}$

$\Rightarrow [m] = \left[\frac{MLT^{-2}}{L^2T^{-2}}\right] = [ML^{-1}T^0]$

13. (a)

14. (d) $\because$ Density, $\rho = \frac{M}{V} = \frac{M}{\pi r^2 L}$

$\Rightarrow \frac{\Delta\rho}{\rho} = \frac{\Delta M}{M} + 2\frac{\Delta r}{r} + \frac{\Delta L}{L}$

$= \frac{0.003}{0.3} + 2\times\frac{0.005}{0.5} + \frac{0.06}{6}$

$= 0.01 + 0.02 + 0.01 = 0.04$

$\therefore$ Percentage error $= \frac{\Delta\rho}{\rho} \times 100 = 0.04 \times 100 = 4\%$

15. (a)

Assertion and Reason

1. (c) Light year and wavelength both represents the distance, so both has dimension of length not of time.

2. (d) Light year measures distance and year measures time. One light year is the distance traveled by light in one year.

3. (a) Addition and subtraction can be done between quantities having same dimension.

4. (c) Density is not always mass per unit volume.

5. (d) Rate of flow of liquid is expressed as the volume of liquid flowing per second and it has dimension $[L^3T^{-1}]$.

6. (a)

7. (a) As the distance of star increases, the parallax angle decreases, and great degree of accuracy is required for its measurement. Keeping in view the practical limitation in measuring the parallax angle, the maximum distance of a star we can measure is limited to 100 light year.

8. (c) Since zeros placed to the left of the number are never significant, but zeros placed to right of the number are significant.

9. (b) The last number is most accurate because it has greatest significant figure (3).

10. (a) As length, mass and time represent our basic scientific notations, therefore they are called fundamental quantities and they cannot be obtained from each other.

11. (c) Because density can be derived from fundamental quantities.

12. (c) Because representation of standard metre in terms of wavelength of light is most accurate.

13. (a) As radar is most accurate instrument used to detect aeroplane in sky based on principle of reflection of radio waves.

14. (c) As surface tension and surface energy both have different S.I. unit and same dimensional formula.

15. (c) As ω (angular velocity) has the dimension of $[T^{-1}]$ not $[T]$.

16. (e) Radian is the unit of plane angle.

17. (b) A.U. is used (Astronomical units) to measure the average distance of the centre of the sun from the centre of the earth, while angstrom is used for very short distances. 1 A.U. = $1.5 \times 10^{11} m$, $1 \mathring{A} = 10^{-10} m$.

18. (c) We know that $Q = n_1u_1 = n_2u_2$ are the two units of measurement of the quantity Q and n_1, n_2 are their respective numerical values. From relation $Q_1 = n_1u_1 = n_2u_2$, nu = constant $\Rightarrow n \propto 1/u$ *i.e.,* smaller the unit of measurement, greater is its numerical value.

19. (c) Dimensional constants are the quantities whose value are constant and they posses dimensions. For example, velocity of light in vacuum, universal gravitational constant, Boltzman constant, Planck's constant etc.

20. (e) Let us write the dimension of various quantities on two sides of the given relation.

L.H.S. $= T = [T]$, R.H.S. $= 2\pi\sqrt{g/l} = \sqrt{\frac{LT^{-2}}{L}} = [T^{-1}]$

($\because 2\pi$ has no dimension). As dimensions of L.H.S. is not equal to dimension of R.H.S. therefore according to principle of homogeneity the relation

$T = 2\pi\sqrt{g/l}$ is not valid.

21. (b) From, $f = \frac{1}{2l}\sqrt{\frac{T}{m}}$, $f^2 = \frac{T}{4l^2m}$

or, $m = \frac{T}{4l^2f^2} = \frac{[MLT^{-2}]}{L^2T^{-2}} = \frac{M}{L} = \frac{\text{Mass}}{\text{length}} =$ linear mass density.

22. (a) According to statement of reason, as the graph is a straight line, $P \propto Q$, or P = constant × Q

i.e. $\frac{P}{Q}$ = constant

23. (c) Avogadro number (N) represents the number of atoms in 1 gram mole of an element, i.e. it has the dimensions of mole^{-1}.

24. (a) Unit of quantity (L/R) is Henry/ohm.

As Henry = ohm × sec, hence unit of L/R is sec i.e.

[L/R] = [T].

Similarly, unit of product CR is farad × ohm or,

$\frac{\text{Coulomb}}{\text{Volt}} \times \frac{\text{Volt}}{\text{Amp}}$ or, $\frac{\text{Sec} \times \text{Amp}}{\text{Amp}}$ or, *sec* i.e.

[CR] =

[T] therefore [L/R] and [CR] both have the same dimension.

25. (b) Both assertion and reason are true but reason is not the correct explanation of assertion.

$[\varepsilon_0] = [M^{-1}L^{-3}T^4I^2]$, $[\mu_0] = [MLT^{-2}I^{-2}]$

$$\Rightarrow \frac{1}{\sqrt{(\mu_0/4\pi) \times 4\pi E_0}} = \sqrt{\frac{9 \times 10^9}{10^{-7}}} = \sqrt{9 \times 10^{16}}$$

$$= 3 \times 10^8 \, m/s$$

Therefore $\frac{1}{\sqrt{\mu_0 \varepsilon_0}}$ has dimension of velocity and numerically equal to velocity of light.