HINTS & SOLUTIONS

EXERCISE - 1

Single Choice

1. (C)

2. $\left[\frac{1}{p}\right]=\left[\frac{mvr}{mv}\right]=[r]=L$

3. $[l]=[mvr]=(MLT^{-1}L)=ML^2T^{-1}$

4. (B)

5. $[x]=[\text{force}\times\text{density}]=MLT^{-2}\frac{M}{L^3}$

6. $\left[\frac{b}{t}\right]=[v] \Rightarrow [b]=LT^{-1}.T=L$

7. $[a]=T^{-1}$

8. $\left[\frac{ax\,c}{bt^2}\right]=\frac{MLT^{-2}\times MLT^{-2}}{MLT^{-2}}=MLT^{-2}$

9. (B)

10. $f=Cm^x.k^y \Rightarrow [f]=[m^x][k^y] \Rightarrow T^{-1}=M^xM^yT^{-2y}$

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

11. Flux $\phi=\vec{E}\times\vec{A}$ so $[\phi]\neq[E]$

& $\vec{p}=q\vec{d}$ so $[p]\neq[E]$

12. $I=Mr^2$

$[I]=ML^2\rightarrow$ momentu of inertia

$[\tau]=[r.F]=[L.MLT^{-2}]=ML^2T^{-2}$

$[\tau]\rightarrow$ moment of force

13. $[E]=ML^2T^{-2}=(MLT^{-2}).(L.T^{-1})(T)=[FTV]$

14. 1 N = x units

$x=\left(\frac{1kg}{10kg}\right)\left(\frac{1m}{100m}\right)\left(\frac{1sec}{60\,sec}\right)^{-2}=\frac{1}{10}\times\frac{1}{100}\times 300$

$\Rightarrow x=3.6$

15. $[A]=T^{-1},[B]=L^{-1},[C]=M^0L^0T^0$

16. $\left[\frac{\alpha}{\beta}\right]=[P]=ML^{-1}T^{-2}$

17. $[a]=[x]=L \Rightarrow [x]=[dt^3] \Rightarrow [d]=LT^{-3}$

18. $[PV]=\left[\frac{a}{v}\right] \Rightarrow ML^2T^{-2}=\frac{[a]}{L^3} \Rightarrow [a]=ML^5T^{-2}$

19. $\frac{ML^2T^{-2}(MLT^{-1}L)^2}{M^5(M^{-1}L^3T^{-2})^2}=M^0L^0T^0$

20. $[k]=L \Rightarrow [k\bullet t]=L^0T^0$

$L[\bullet]=T=L^0T^0 \Rightarrow [\bullet]=L^{-1}T^{-1}$

EXERCISE - 2

Part # I : Multiple Choice

1. (A, B, C), $[\alpha]=\frac{[h]}{[\sigma\theta^4]}=\frac{ML^2T^{-1}}{MT^{-3}K^{-4}K^4}=L^2T^2$

So, unit of α will be m^2s^2

$\frac{(\text{weber})(\Omega)^2(\text{farad})^2}{\text{Tesla}}=\frac{Tm^2.\Omega^2F^2}{T}=m^2s^2$

2. (A, B, C)

3. (A, B, D)

4. (D), $n_1u_1=n_2u_2$

$\therefore \frac{n_2}{n_1}=\frac{u_1}{u_2}=\frac{M_1^{-1}L_1^3T_1^{-2}}{M_2^{-1}L_2^3T_2^{-2}}=\frac{M^{-1}L^3T^{-2}}{M^{-1}(2L)^3T^{-2}}=\frac{1}{8}$

5. (C)

6. (A) $\left[\frac{b}{c}\right]=\left[\frac{1/t}{1/x}\right]=\left[\frac{x}{t}\right]=$ wave velocity

7. (C) $[k]=[\rho][v^2]=[ML^{-3}][L^2T^{-2}]=ML^{-1}T^{-2}$

$=\frac{\text{Force}}{\text{Area}}=$ Modulus of elasticity

8. (D) $\frac{A}{B}=m \quad \therefore \quad B=\frac{A}{m}$

$[B]=\left[\frac{MLT^{-1}}{ML^{-1}}\right]=[L^2T^{-2}]=$ latent heat

9. (A)

10. (B) $C\equiv LT^{-1}, G\equiv M^{-1}L^3T^{-2}, h\equiv M^1L^2T^{-1}$

$\Rightarrow M=\sqrt{\frac{hc}{G}}$

Part # II : Assertion & Reason

1. (A)	2. (C)	3. (C)	4. (A)
5. (E)	6. (A)	7. (A)	8. (D)

EXERCISE - 3

Part # I : Matrix Match Type

1. (1) $\rightarrow$ (Q) $\rightarrow$ (C) (2) $\rightarrow$ (S) $\rightarrow$ (A)
(3) $\rightarrow$ (P) $\rightarrow$ (B) (4) $\rightarrow$ (R) $\rightarrow$ (D)

$$F = G = \frac{m_1 m_2}{r^2} \quad [G] = \frac{[F][r^2]}{[m_1 m_2]} = \frac{[MLT^{-2}]^2}{M^2} = M^{-1}L^3T^{-2}$$

$[\text{Torque}] = [f][d] = MLT^{-2}L = ML^2T^{-2}$
$[\text{Momentum}] = [m][v] = MLT^{-1}$

$$[p] = \frac{[F]}{[A]} = \frac{MLT^{-2}}{L^2} = ML^{-1}T^{-2}$$

2. (A) $\rightarrow$ (T) ; (B) $\rightarrow$ (P) ; (C) $\rightarrow$ (R) ; (D) $\rightarrow$ (Q) ; (E) $\rightarrow$ (S)
3. (A) $\rightarrow$ (Q) ; (B) $\rightarrow$ (P) ; (C) $\rightarrow$ (R) ; (D) $\rightarrow$ (V) ;
(E) $\rightarrow$ (S) ; (F) $\rightarrow$ (T, U)
4. (A) $\rightarrow$ (R) ; (B) $\rightarrow$ (S) ; (C) $\rightarrow$ (T) ; (D) $\rightarrow$ (Q) ; (E) $\rightarrow$ (P)
5. (A) $\rightarrow$ (Q) ; (B) $\rightarrow$ (R) ; (C) $\rightarrow$ (S) ; (D) $\rightarrow$ (P)

Part # II : Comprehension

Comprehension # 1 :

1. $[b] = [V]$

2. $\left[\frac{a}{V^2}\right] = [P] \Rightarrow [a] = [PV^2]$

3. $[PV] = [RT], [Pb] = [PV] = [RT]$

$$\frac{1}{2} \text{ and } \left[\frac{ab}{V^2}\right] = \left[\frac{(PV^2)V}{V^2}\right] = [PV] = [RT]$$

4. $\left[\frac{ab}{RT}\right] = \left[\frac{PV^3}{PV}\right] = [V^2] = M^0L^6T^0$

5. $[RT] = [PV] = (ML^{-1}T^{-2})(L^3) = ML^2T^{-2} = [\text{Energy}]$

Comprehension # 2 :

1. Let unit of length, time and mass be L_1, T_1 and M_1 respectively.
According to question $9.8\,LT^{-2} = 3L_1T_1^{-2}$

$$\frac{1}{2}(272.1)(448)^2ML^2T^{-2} = 100\,M_1L_1^2T_1^{-2}$$

$(272.1)(448)\,MLT^{-1} = 10\,M_1L_1T_1$
by solving above equation $L_1 = 153.6$
$L = 153.6\text{ m}$

2. By solving above equation $T_1 = 6.857$
$T = 6.857\text{ s}$

3. By solving above equation $M_1 = 544.2$
$M = 544.2\text{ kg}$

EXERCISE - 4

Subjective Type

1. $[\mu x] = M^0L^0T^0$

$[\mu]\,[x] = M^0L^0T^0 \Rightarrow [\mu] = \frac{1}{L} = L^{-1}$

2. $[\text{mass}] \alpha c^a G^b h^c$

$$[M] = k[LT^{-1}]^a \frac{k}{L}\sqrt{\frac{F}{m}}\,[ML^2T^{-1}]^c$$

[k $\rightarrow$ Proporsionality constant]

$[M] = k[LT^{-1}][M^{-1}L^3T^{-2}]^b\,[ML^2T^{-1}]^c$

$a = \frac{1}{2}, b = -\frac{1}{2}, c = \frac{1}{2}, M = kc^{-1/2}, G^{-1/2}, h^{1/2}$

Same way we can, $L = kc^{-3/2}G^{1/2}h^{1/2}$, $T = kc^{-5/2}G^{1/2}h^{1/2}$

3. Frequency $\propto L^aF^b(m)^c = L^aF^b\left(\frac{M}{L}\right)^c$

$$\frac{1}{T} = kL^a(MLT^{-2})^b\left(\frac{M}{L}\right)^c$$

[k $\rightarrow$ Proporsionality constant]
$T^{-1} = kL^{a+b-c}\,M^{b+c}\,T^{-2c}$

On comparing $c = -\frac{1}{2}$, $b = +\frac{1}{2}$, $a = 1$

$$\text{frequency} = \frac{k}{L}\sqrt{\frac{F}{m}}$$

4. $E = h\nu \Rightarrow [E] = [h]\,[\nu] \Rightarrow ML^2T^{-2} = [h]\frac{1}{T}$

$[h] = M\,L^2\,T^{-1}$

5. (a) $[c] = \frac{[Q]}{[m][T_2 - T_1]} \Rightarrow [c] = L^2T^{-2}k^{-1}$

(b) $[l_t]\,[l_0] = [l_0\alpha(T_2 - T_1)] \Rightarrow [\alpha] = k^{-1}$

(c) $[R] = \frac{[pv]}{[nT]} = \frac{ML^{-1}T^{-2}L^3}{\text{mol k}} = ML^2T^{-2}k^{-1}\,\text{mol}^{-1}]$

6. $U_x = (1 - \cos ax)$
$[ax]$ is dimension less ; $[a] = L^{-1}$
$[U_x] = [k] \Rightarrow [k] = ML^2T^{-2}$

7. $T\mu(r)^a(m)^b(G)^c$ & $[G] = \frac{[F]L^2}{M^2} = M^{-1}L^3T^{-2}$

$\Rightarrow [T] = k(L)^a(M)^b(M^{-1}L^3T^{-2})^c$
[k $\rightarrow$ Proporsionality constant]
$T = L^{a+3c}\,M^{b-c}\,T^{-2c}$

$\Rightarrow a + 3c = 0, -2c = 1 \Rightarrow c = -\frac{1}{2}$

$b - c = 0 \Rightarrow a = \frac{3}{2}, b = -\frac{1}{2}$

$\Rightarrow T = \frac{k\, r^{\frac{3}{2}}}{M^{\frac{1}{2}}(G)^{\frac{1}{2}}} \Rightarrow T^2 = \frac{K^2 r^3}{GM}$

8. $\omega \propto r^a m^b G^c$

$\omega = k[L]^a [M]^b [M^{-1}L^3T^{-2}]^c$, $T^{-1} = kL^{a+3c}M^{b-c}T^{-2c}$

$c = \frac{1}{2}, b = \frac{1}{2}, a = -\frac{3}{2} \Rightarrow \omega = k\sqrt{\frac{GM}{r^3}}$

9. $[v] = T^{-1}$

$\left[\frac{1}{2\pi}\sqrt{\frac{mgl}{I}}\right] = \left[\sqrt{\frac{mgl}{I}}\right] = \sqrt{\frac{mLT^{-2}L}{ML^2}} = T^{-1}$

So. this equation is dimensionally correct.

10. $F \propto (\rho)^a (v)^b (A)^c$

$F = k(\rho)^a (v)^b (A)^c$ [$k \rightarrow$ Proporsionality constant]

$\Rightarrow$ $MLT^2 = k(ML^3)^a (LT^{-1})^b (L^2)^c$

$\Rightarrow$ $a = 1, -3a - b + 2c = 0, \Rightarrow -b + 2c = 3$

& $-b = -2 \Rightarrow b = 2$

$\Rightarrow$ $F = (\rho)(V)^2(A)^1 \quad \Rightarrow f \propto V^2$

11. $T = k(\rho)^a (r)^b (s)^c$ [$k \rightarrow$ Proporsionality constant]

where ρ = density $\Rightarrow$ $[\rho] = ML^{-3}$

r = radius $\Rightarrow$ $[r] = L$

s = surface tension $\Rightarrow$ $[s] = ML^{-2}$

$[T] = k[ML^{-3}]^a [L]^b [MT^{-2}]^c$

$T = kM^{a+c} L^{-3a+b} T^{-2c}$

$a + c = 0, -3a + b = 0, 2c = 1 \Rightarrow c = -\frac{1}{2}$

$a = \frac{1}{2}, b = \frac{3}{2} \Rightarrow T = \frac{k(\rho)^{\frac{1}{2}}(r)^{\frac{3}{2}}}{(s)^{\frac{1}{2}}} = k\sqrt{\frac{\rho r^3}{s}}$

12. $[E] = \frac{F/A}{\left(\frac{\Delta V}{V}\right)} = ML^{-1}T^{-2} \Rightarrow [\rho] = ML^{-3}$

Let $v = k(E)^a (\rho)^b$, [$k \rightarrow$ Proporsionality constant]

$LT^{-1} = (mL^{-1}T^{-2})^a (ML^{-3})^b$

$a + b = 0 ; -a - 3b = 1 ; -2a = -1 \Rightarrow a = \frac{1}{2}, b = -\frac{1}{2}$

So, $v = k\, E^{1/2} \rho^{-1/2} = k\sqrt{\frac{K}{\rho}}$

EXERCISE - 5

Part # I : AIEEE/JEE-MAIN

1. The dimensions of torque and work are $[ML^2T^2]$

2. h = Planck's constant = J – s = $[ML^2T^{-1}]$

P = momentum = kg m/s = $[MLT^{-1}]$

3. As we know that formula of velocity is

$$v = \frac{1}{\sqrt{\mu_0 \varepsilon(0)}}$$

$\therefore v^2 = \frac{1}{\mu_0\varepsilon_0} = [LT^{-1}]^2 \quad \therefore \frac{1}{\mu_0\varepsilon_0} = [L^2T^{-2}]$

4. From Newtons' formula

$$\eta = \frac{F}{A(\Delta v_x / \Delta z)}$$

$\therefore$ Dimension of η =

$$\frac{\text{dimensions of force}}{\text{dimesnsions area} \times \text{dimensions of velocity} - \text{gradient}}$$

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

5. $I = mr^2$

$\therefore$ $[I]\,[ML^2]$

and $\vec{\tau}$ = moment of force = $\vec{r} \times \vec{F}$

$\therefore$ $[\vec{\tau}] = [L]\,[MLT^{-2}]$

6. Energy stored in inductor

$U = \frac{1}{2}Li^2 \Rightarrow L = \frac{2U}{I^2}$

$[L] = \frac{ML^2T^{-2}}{Q^2/T^2} = \frac{ML^2}{Q^2}$

Since Henry is unit of inductance L

7. From $F = qvB$ is

$\Rightarrow$ $[MLT^{-2}] = [C]\,[LT^{-1}]\,[B]$

$\Rightarrow$ $[B] = [MC^{-1}T^{-1}]$

8. $F = \frac{1}{4\pi\varepsilon_0}\frac{q_2 q_2}{R^2}$; $\varepsilon_0 = \frac{q_1 q_2}{4\pi F R^2}$

Hence $\varepsilon_0 = \frac{C^2}{Nm^2} = \frac{[AT]^2}{MLT^{-2}.L^2} = [M^{-1} L^{-3} T^4 A^2]$

Part # II : IIT-JEE ADVANCED

1. Reynold's number and coefficient of friction are dimensionless quantities. Curie is the number of atoms decaying per unit time and frequency is the number of oscilations per unit time. Latent heat and gravitational potential both have the same dimension corresponding to energy per unit mass.

2. $X = 3YZ^2$
$[X] = [Y]\,[Z]^2$
$$[Y] = \frac{[X]}{[Z]^2} = \frac{M^{-1}L^{-2}Q^2T^2}{M^2Q^{-2}T^{-2}} = M^{-3}L^{-2}Q^4T^4$$

3. Torque and work have same dimensions $= ML^2T^{-2}$
Light year and wavelenth have dimension of length = L

4. Micron, light year & angstrom are untis of length adnd radian's unit of angle.

5. (A) $L = \dfrac{\phi}{i}$ or $\text{Henry} = \dfrac{\text{Weber}}{\text{Ampere}}$

(B) $e = -\,L\left(\dfrac{di}{dt}\right)$

$\therefore$ $L = \dfrac{e}{di/dt}$ or $\text{Henry} = \dfrac{\text{Volt}-\text{second}}{\text{Ampere}}$

(C) $U = \dfrac{1}{2}Li^2$ or $\text{Henry} = \dfrac{\text{Joule}}{(\text{Ampere})^2}$

(D) $U = \dfrac{1}{2}Li^2$ or Henry = ohm - second

6. we have $F = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q_1q_2}{r^2}$
$$[\varepsilon_0] = \frac{[q_1][q_2]}{[F][r^2]} = \frac{I^2T^2}{MLT^{-2}T^2} = M^{-1}L^{-3}T^4I^2$$
Also C (speed of light) $= \dfrac{1}{\sqrt{\varepsilon_0\mu_0}}$
$$\therefore\quad [\mu_0]^{1/2} = \frac{1}{[C][\epsilon_0]}$$
$[\mu_0] = MLT^{-2}I^{-2}$

7. (None of the four choices) $\dfrac{1}{2}\epsilon_0 E^2$ is the expression of energy density (Energy per unit volume)
$$\therefore\quad \left[\frac{1}{2}\epsilon_0 E^2\right] = \left[\frac{ML^2T^{-2}}{L^3}\right]$$
From this question, students can take a lesson that even in IIT-JEE, questions may be wrong or there may be no correct answer ins the given choices. So don't wastetime if you are confident.

8. $X = \varepsilon_0 L\dfrac{\Delta v}{\Delta t}$
$$[X] = [\varepsilon_0]\,[L]\left[\frac{\Delta v}{\Delta t}\right]$$
$[\Delta v]$ = [Electric field] [Length]
$$= \frac{[\text{Force}]}{[\text{Charge}]}[\text{Length}] = \frac{MLT^{-2}L}{Q} = MQ^{-1}L^2T^2$$
$= QT^{-1} = 1$
$\therefore$ [X] is that of current

9. $\left[\dfrac{\alpha Z}{k\theta}\right] = [M^0 L^0 T^0] \Rightarrow [\alpha] = \left[\dfrac{K\theta}{Z}\right]$

Further, $[P] = \left[\dfrac{\alpha}{\beta}\right] \Rightarrow [\beta] = \left[\dfrac{\alpha}{P}\right] = \left[\dfrac{k\theta}{ZP}\right]$

Dimensions of $K\theta$ are that of energy. Hence,
$$[\beta] = \left[\frac{ML^2T-^2}{LML^{-1}T^{-2}}\right] = [M^0L^2T^0]$$
There, the correct option is **(A)**.

11. (A) $\dfrac{GM_eM_s}{R_e^2}$ = Force

$[GM_eM_s] = [\text{Force}]\,[R_e^2]$
$= MLT^{-2}L^2 = ML^3T^{-2}$

Hence SI unit of GM_eM_s, will be (kilogram) (meter^3) (sec^{-2}) ie same as (volt) (coulomb) (meter)

(B) $\sqrt{\dfrac{3RT}{M_0}} = V_{R.M.S.}$
$$\left[\frac{3RT}{M_0}\right] = [V_{R.M.S.}] = L^2T^{-2}$$
Hence SI unit will be (metre)^2 (second)^2
i.e. same as (farad) (volt)^2 (kg)$^{-1}$

(C) $\dfrac{[F^2]}{[q^2B^2]} = \dfrac{[q^2v^2B^2]}{[q^2B^2]} = L^2T^{-2}$

Hence SI unit (metre)^2 (second)^2
i.e. same as (farad) (volt)^2 (kg)$^{-1}$

(D) $\left[\frac{GM_e}{R_e}\right] = \frac{[Force][R_e]}{[Mass]} = \frac{MLT^{-2}L}{M} = L^2T^{-2}$

Hence SI unit will be $(meter)^{-2}$ (second)

i.e. same as (farad) $(volt)^2$ $(kg)^{-1}$

12. **(p)** $U = \frac{1}{2}kT \Rightarrow ML^2T^{-2} = [k]K$

$\Rightarrow [K] = ML^2T^{-2}K^{-1}$

(q) $F = \eta A\frac{dv}{dx}$

$\Rightarrow [\eta] = \frac{MLT^{-2}}{L^2LT^{-1}L^{-1}} = ML^{-1}T^{-1}$

(r) $E = hv \Rightarrow ML^2T^2 = [h]T^{-1}$

$\Rightarrow [h] = ML^2T^{-1}$

(s) $\frac{dQ}{dt} = \frac{kA\Delta\theta}{l} \Rightarrow [k] = \frac{ML^2T^{-3}}{L^2k}$

$= MLT^{-3}K^{-1}$

13. **3**

14. **A,C,D** $P = \frac{h}{\lambda}$

$M^1L^1T^{-1} = \frac{h}{L^1} \Rightarrow L^2 \propto h \Rightarrow L \propto \sqrt{h}$

15. **(A)** $\mu_0 I^2 = \varepsilon_0 V^2$

$C = \frac{1}{\sqrt{\mu_0\varepsilon_0}} \Rightarrow \mu_0 I^2 = \varepsilon_0 V^2 \Rightarrow \frac{\mu_0}{\varepsilon_0} = \frac{V^2}{I^2}$

$\Rightarrow C^2 = \frac{1}{\mu_0\varepsilon_0} \Rightarrow \frac{1}{C^2\varepsilon_0} = \frac{V^2}{I^2} \quad \mu_0 \frac{1}{C^2\varepsilon_0}$

$k = \frac{1}{4\pi\varepsilon_0} = \frac{Nm^2}{C^2} \Rightarrow$ (C) $I = \varepsilon_0 CV$

again matches. **(solved & get)**

16. **BD**

MOCK TEST

1. **(A)** **2.** **(B)** **3.** **(C)**

4. $\left[\frac{E^2}{\mu_0}\right] = \left[\frac{\varepsilon_0 E^2}{\varepsilon_0\mu_0}\right] = \left[\frac{\text{energy / volume}}{(1/\text{speed of light})^2}\right]$

$= \left[\frac{\text{energy(speed)}^2}{\text{volume}}\right] = \left[\frac{ML^2T^{-2}L^2T^{-2}}{L^2}\right] = [MLT^{-4}]$

5. $\lambda_m T = b$ or $b^4 = \lambda_m^4 T^4$ and $\frac{\text{energy}}{\text{area time}} = \sigma T^4$

or $\sigma = \frac{\text{energy}}{\text{area time } T^4}$ $\therefore$ $\sigma b^4 = \left(\frac{\text{energy}}{\text{area time}}\right)\lambda_m^4$

or $[\sigma b^4] = \frac{[ML^2T^{-2}]}{[L^2][T]}[L^4] = [ML^4T^{-3}]$

6. $P = \frac{a - t^2}{bx} \Rightarrow Pbx = a - t^2 \Rightarrow [Pbx] = [a] = [T^2]$

or $[b] = \frac{[T^2]}{[P][x]} = \frac{[T^2]}{[ML^{-1}T^{-2}][L]} = [M^{-1}T^4]$

$\therefore \left[\frac{a}{b}\right] = \left[\frac{T^2}{M^{-1}T^4}\right] = [MT^{-2}]$

7. The quantity $\frac{t}{a} - 1$ is dimensionless i. e., $[a] = [t]$

$\therefore [\sqrt{2at - t^2}] = [t]$ or $\left[\frac{dt}{\sqrt{2at - t^2}}\right] = \left[\frac{t}{t}\right] = [m^0L^0T^0]$

i.e., a^x should also be dimensionless. or $x = 0$

8. $[hc] = [hc] = [E\lambda] = [ML^2T^{-2}L] = [ML^3T^{-2}]$

9. $U(x) = K|x|^3$

$\therefore [K] = \frac{[U]}{[x]^3} = \frac{[ML^2T^{-2}]}{[L^3]} = [ML^{-1}T^{-2}]$

Now time period may depend on

$T \propto (mass)^x (amplitude)^y (K)^z$

or $[M^0L^0T] = [M]^x [L]^y [ML^{-1}T^{-2}]^z = [M^{x+z} L^{y-z} T^{-2z}]$

Equating the powers, we get

$-2z = 1$ or $z = -1/2$

$y - z = 0$ or $y = z = -1/2$

$\therefore$ $T \propto (amplitude)^{-1/2}$

or $T \propto (a)^{-1/2}$ or $T \propto \frac{1}{\sqrt{a}}$

10. $[Y] = \left[\frac{X}{Z^2}\right] = \left[\frac{\text{Capacitance}}{(\text{Magnetic induction})^2}\right]$

$= \left[\frac{M^{-1}L^{-2}Q^2T^2}{M^2Q^{-2}T^{-2}}\right] = [M^{-3}L^{-2}Q^4T^4]$

11. $\frac{1}{2}\varepsilon_0 E^2$ is the expression of energy density

(Energy per unit volume)

$= \left[\frac{1}{2}\varepsilon_0 E^2\right] = \left[\frac{ML^2T^{-2}}{L^3}\right] = [ML^{-1}T^{-2}]$

12. $\left[\frac{\alpha z}{k\theta}\right] = [M^0L^0T^0] \Rightarrow [\alpha] = \left[\frac{k\theta}{Z}\right]$

Further $[P] = \left[\frac{\alpha}{\beta}\right]$ $\therefore [\beta] = \left[\frac{\alpha}{p}\right] = \left[\frac{k\theta}{ZP}\right]$

Dimensions of K θ is that to energy. Hence,

$$[\beta] = \left[\frac{ML^2T^{-2}}{LML^{-1}T^{-2}}\right] = [M^0L^2T^0]$$

13 **(D)**

14. $F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1q_2}{r^2}$

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

Speed of light, $c = \frac{1}{\sqrt{\varepsilon_0\mu_0}}$

$$\therefore [\mu_0] = \frac{1}{[\varepsilon_0][c]^2} = \frac{1}{[M^{-1}L^{-3}T^4I^2][LT^{-1}]^2}$$

15. **(A)** $L = \frac{\phi}{i}$ or henry $= \frac{\text{weber}}{\text{ampere}}$

(B) $e = -L\left(\frac{di}{dt}\right)$ $\therefore L = -\frac{e}{(di/dt)}$

or henry $= \frac{\text{volt} - \text{second}}{\text{ampere}}$

(C) $U = \frac{1}{2}Li^2$ $\therefore L = \frac{2U}{i^2} = \frac{\text{joule}}{(\text{ampere})^2}$

(D) $U = \frac{1}{2}Li^2 = i^2 Rt$

$\therefore$ L = Rt or henry = ohm-second

16. **(A)** Strain and coefficient of friction both are dimensionless.

(B) Disintegration constant and frequency of light both have dimensions $[T^{-1}]$.

(C) Heat capacity has unit cal/kg while gravitational potential has unit J/kg e.e., both have dimensions $[L^2T^{-2}]$.

17. Time constant in C-R and L-R circuits are CR and $\frac{L}{R}$ respectively.

Hence, $CR = \frac{L}{R}$ or $CR^2 = L$

i.e., units of CR^2 and L are same.

Now $|e| = L\left(\frac{di}{dt}\right)$ and $U = \frac{1}{2}Li^2$

Therefore, units of L or CR^2 are henry,

$\frac{\text{volt} - \text{second}}{\text{ampere}}$ and joule/ampere^2

18. ε_0E_2 has the dimensions of energy per unit volume or force per unit area. Force per unit area is pressure and energy per unit volume of an ideal gas at temperature T is $\frac{3}{2}$KfT. Hence, the correct options are (A) and (B).

19. Torque and energy have same dimension but different units.

20. Velocity, volume and acceleration cannot be taken as basic variables as they are not independent $[\text{velocity}]^6 = [\text{acceleration}]^3\,[\text{volume}]$.

21. Same physical quantities can be added or subtracted and same dimensional formula does not ensure same physical quantities.

22. **(A)** $\frac{GM_eM_s}{{R_e}^2} = \text{Force}$

$[GM_eM_s] = [\text{Force}]\,[R_e^2] = MLT^{-2}L^2 = ML^3T^{-2}$

Hence SI unit of GM_eM_s will be (kilogram) (meter^3)(sec^{-2})

i.e. same as (volt) (coulomb) (metre)

(B) $\sqrt{\frac{3RT}{M}} = V_{R.M.S.} \Rightarrow \left[\frac{3RT}{M_0}\right] = [V_{R.M.S.}]^2 = L^2T^{-2}$

Hence SI unit will be (metre)^2 (second)$^{-2}$

i.e. same as (farad) (volt)^2 (kg)$^{-1}$

(C) $\frac{[F^2]}{[q^2B^2]} = \frac{[q^2v^2B^2]}{[q^2B^2]} = [V^2] = L^2T^{-2}$

Hence SI unit (metre)^2 (second)$^{-2}$

i.e. same as (farad) (volt)^2 (kg)$^{-1}$

(D) $\left[\frac{GM_e}{R_e}\right] = \frac{[\text{Force}][R_e]}{[\text{Mass}]} = \frac{MLT^{-2}L}{M} = L^2T^{-2}$

Hence SI unit will be (meter)$^{-2}$ (second)$^{-2}$

i.e. same as (farad) (volt)^2 (kg)$^{-1}$