Solution

PHYSICS

Class 12 - Physics

Section A

1. Select and write the correct answers for the following multiple choice type of questions:

(i) **(b)** the photoelectric current
Explanation: {
the photoelectric current

(ii) **(a)** energy
Explanation: {
energy

(iii) **(d)** all inputs are low
Explanation: {
all inputs are low

(iv) **(a)** $\sqrt{3}$
Explanation: {
$n=\tan \theta_B=\tan 60^{\circ}=\sqrt{3}$

(v) **(d)** Frequency
Explanation: {
Frequency

(vi) **(b)** capillarity
Explanation: {
capillarity

(vii) **(b)** 2nd orbit
Explanation: {
2nd orbit

(viii) **(d)** low coercivity and low retentivity
Explanation: {
Coercivity is the measure of a material's resistance to changes in its magnetization state. Since soft iron can be easily magnetized and demagnetized with a relatively small applied magnetic field, it has low coercivity.
Retentivity is the ability of a material to retain its magnetization once the external magnetic field is removed. Since soft iron does not hold on to its magnetization when the external magnetic field is removed, it has low retentivity.
Thus, soft iron's low coercivity allows it to easily switch between magnetized and demagnetized states with minimal energy loss, while its low retentivity ensures that it does not retain magnetization between alternating cycles.
These properties make soft iron an ideal material for transformer cores, where rapid and reversible changes in magnetization are essential for the efficient transfer of electrical energy.

(ix) **(c)** $\sqrt{T}$
Explanation: {
$\sqrt{T}$

(x) **(b)** indium
Explanation: {
indium

2. Answer the following questions:

(i) Einstein's photoelectric equation:
$K \cdot E_{\max }=(\mathrm{h} v-\phi_0)$

(ii) **Differential equation for angular S.H.M.:**
$I \frac{d^2 \theta}{d t^2}+c \theta=0$

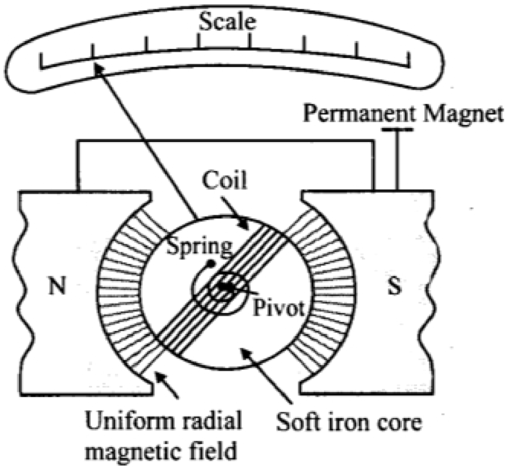
(iii) Average value of alternating current over a complete cycle is zero.

(iv) Potential gradient is defined as potential difference per unit length of wire.
(v) No, vehicle will skid in the absence of friction on the road.
(vi) H_2O- polar dielectric

CO_2- non-polar dielectric

(vii) Force on a closed circuit in a magnetic field is zero.
(viii) When the rod of diamagnetic material is placed in a non-uniform magnetic field, it tends to move from stronger part to the weaker part of the magnetic field.

Section B

3. i. Coefficient of viscosity: The coefficient of viscosity is defined as the viscous force per unit area per unit velocity gradient.
   ii. Formula: $\eta = \frac{F}{\frac{dv}{dx}}$
   iii. Unit of η is Ns/m^2 or decapoise in S.I. system
4. 

5. **Statement and explanation:**
   Angular momentum of an isolated system is conserved in the absence of an external unbalanced torque.
   Examples:
   i. The angular velocity of revolution of a planet around the sun in an elliptical orbit increases, when the planet comes closer to the sun and vice-versa.
   ii. A person carrying heavy weights in his hands and standing on a rotating platform can change the speed of the platform.
   iii. A diver performs somersaults by jumping from a high diving board keeping his legs and arms out stretched first, and then curling his body.
6. i. The ability of a conductor to store the electric charge is called capacitance of conductor.
   ii. SI unit of capacity of conductor is farad (F).
   $\therefore 1\ F = \frac{1C}{1\ V}$
   Thus, the capacity of a conductor is said to be 1 farad if the potential difference across it rises by 1 volt, when 1C charge is given to it.
7. i. A simple pendulum whose period is two seconds is called second's pendulum.
   ii. Time period of simple pendulum, $T = 2\pi\sqrt{\frac{L}{g}}$
   For a second's pendulum, $2 = 2\pi\sqrt{\frac{L_s}{g}}$
   Where, L_s is the length of second's pendulum, having period $T = 2\ s$.
   $\therefore L_s = \frac{g}{\pi^2}$
8. **Thermodynamic process:** A process by which two or more of state variables of a system can be changed is called a thermodynamic process or a thermodynamic change.
   Types of thermodynamic processes:
   i. Quasi-static process
   ii. isothermal process
   iii. adiabatic process
   iv. isochoric process
   v. isobaric process

vi. reversible process
vii. irreversible process
viii. cyclic process

(Any two types)

9. Given: $L=0.1H, C=25\times10^{-6}\ F, R=15\Omega$
$e_{rms}=120\ V$
To find: Resonant frequency (f_r)
Formula: $f_r=\frac{1}{2\pi\sqrt{LC}}$
Calculation: From formula,
$f_r=\frac{1}{2\times3.142\times\sqrt{0.1\times25\times10^{-6}}}$
$=\frac{1}{9.9356\times10^{-3}}$
$f_r=100.6\ Hz$
The value of resonant frequency is $100.6 Hz$.

10. Given: $2A=20\ cm$
$\therefore$ A = 10 cm,
$T=6.28\ s, x=6\ cm$
To find: Velocity (v)
Formula: $v=\omega\sqrt{A^2-x^2}$
Calculation: Since, $\omega=\frac{2\pi}{\mathrm{T}}=\frac{2\times3.14}{6.28}=1\mathrm{rad/s}$
$\therefore v=(1)\sqrt{(10)^2-(6)^2}\ =\sqrt{100-36}=8cm/s$
The velocity of the particle at x = 6 cm is **8 cm/s.**

11.

Free vibrations	Forced vibration
i. Free vibrations are produced when a body is disturbed from its equilibrium position and released.	Forced vibrations are produced by an external periodic force of any frequency.
ii. To start free vibrations, the force is required initially only.	Continuous external periodic force is required. If external periodic force is stopped, then forced vibrations also stop.

12. Given: $A=200\ cm^2=200\times10^{-4}m^2$,
$T=127^\circ C=(127+273)K=400\ K$
$t=0.5\ min=30\ s$;
Also, $\sigma=5.7\times10^{-8}Jm^{-2}s^{-1}K^{-4}$
To find: Energy radiated (Q)
Formula: $Q=\sigma AtT^4$
Calculation: From formula,
$Q=\sigma AtT^4$
$=5.7\times10^{-8}\times200\times10^{-4}\times30\times(400)^4$
$=5.7\times10^{-8}\times0.6\times10^4\times10^{-4}\times4^4\times10^8$
$=5.7\times0.6\times256=875.5\ J$
Energy radiated in one minute is $875.5\ J$.

13. Given: $G=25\Omega, I_g=10\ mA=10\times10^{-3}\ A$
$V=100\ V$
To find: Resistance (R_s)
Formula: $R_s=\frac{V}{I_g}-G$
Calculation: From formula,
$R_s=\frac{100}{10\times10^{-3}}-25$
$=10^4-25$
$=10000-25$
$=9975\Omega$
A resistance of 9975Ω should be connected in series.

14. Solution:
Given: $E_1=-13.6eV, n_2=5, n_1=1$

To find: Ionisation energy

Formulae: i. $\frac{E_5}{E_1} = \frac{n_1^2}{n_2^2}$

ii. Ionisation energy $= E_\infty - E_n$.

Calculation: Using formula (i), $\frac{E_5}{-13.6} = \frac{1^2}{5^2}$

$\therefore E_5 = \frac{-13.6}{25} = -0.544 eV$

Using formula (ii),

Ionisation energy $= E_\infty - E_5 = 0 - (-0.544) = 0.544 eV$

Ionisation energy for given atom is $0.544\ eV$.

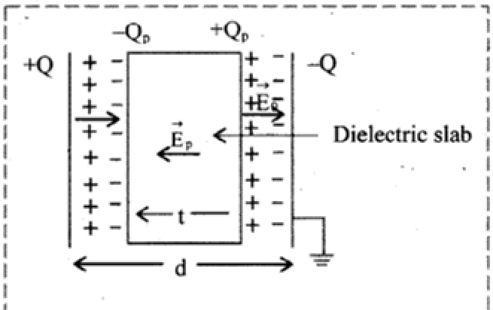
Section C

15. The bending of light near the edge of an obstacle or slit and spreading into the region of geometrical shadow is called diffraction of light.

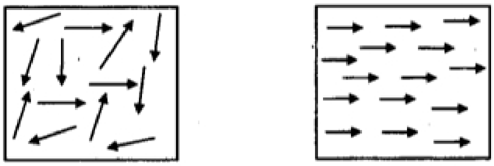
    Two types of diffraction are:

    i. Fraunhofer diffraction:
       a. If the distances between the primary source of light, the obstacle/slit causing diffraction and the screen for viewing the diffraction pattern are very large, the diffraction is called Fraunhofer diffraction.
       b. In this case, the wavefront incident on the obstacle can be considered to be a plane wavefront.

    ii. Fresnel diffraction: In this case, the distances are much smaller and the incident wavefront is either cylindrical or spherical depending on the source.

16. 

Parallel plate capacitor with a dielectric slab between the

17. 
No external magnetic field

Strong external magnetic field

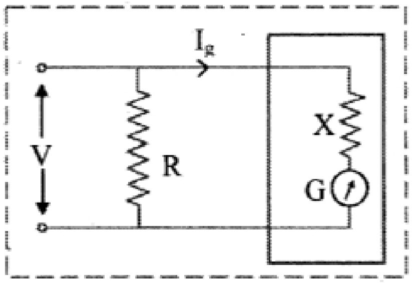
18. The phenomenon of emission of electrons from a metal surface, when radiation of appropriate frequency is incident on it, is known as photoelectric effect.

    i. If increasingly negative potentials were applied to the collector in experiment of photoelectric effect, the photocurrent decreases and for some typical value $(-V_0)$, photocurrent becomes zero. This value of V_0 is termed as cut-off or stopping potential.

    ii. The minimum amount of energy required to be provided to an electron to pull it out of the metal from the surface is called the work function of the metal.

19. i. To use a M.C.G as a voltmeter, a high resistance is connected in series with the M.C.G.

    ii. A very high resistance X is connected in series with the galvanometer for this purpose as shown in figure.



iii. If V is the voltage to be measured, then

$V = I_g X + I_g G$

$\therefore I_g X = V - I_g G$

$\therefore X = \frac{V}{I_g} - G$ ...(1)

where I_g is the current flowing through the galvanometer.

iv. If voltage V is n_v times voltage V_g (voltage across galvanometer) then,

$V = n_v V_g = n_v (I_g G)$

Using this in equation (1),

$X = G(n_v - 1)$.

20. i. **Reflection from a denser medium:**

a. In case of a longitudinal wave, a compression is reflected back as a compression and a rarefaction is reflected back as a rarefaction.

b. In case of a transverse wave, a crest is reflected back as a trough and a trough is reflected as a crest.

ii. **Reflection from a rarer medium:**

a. In case of a longitudinal wave, a compression is reflected as a rarefaction and a rarefaction is reflected as a compression.

b. In case of transverse wave, a crest is reflected as a crest and a trough is reflected as a trough.

21. i. For parallel combination of two coils, the current through each parallel inductor is a fraction of the total current and the voltage across each parallel inductor is same.

ii. As a result, a change in total current will result in less voltage dropped across the parallel array than for any one of the individual inductors.

iii. There will be less voltage drop across parallel inductors for a given rate of change in current than for any of the individual inductors.

iv. Less voltage for the same rate of change in current results in less inductance.

v. Thus, the total inductance of two coils is less than the inductance of either coil.

22. Given: $P = 21, Y = 4$ beat $/s, n_F = 2n_L$

To find:

i. Frequency of first fork (n_F)

ii. Frequency of tenth fork (n_{10})

Formula: $n_L = n_F - (P-1)Y$

Calculation:

i. When tuning forks are arranged in the decreasing order of frequencies, the frequency of the p^{th} tuning fork is,

$n_L = n_F - (P-1)Y = n_1 - (21-1)4$

$\therefore n_L = n_F - 80$

As frequency of first fork is an octave of last,

$\therefore n_F = 2n_L$

$\therefore n_L = \frac{n_F}{2}$

From equation (1),

$\frac{n_F}{2} = n_F - 80$

$\therefore n_F - \frac{n_F}{2} = 80$

$\therefore \frac{n_F}{2} = 80$

$\therefore n_F = 160\ Hz$

ii. For 10^{th} fork,

$n_{10} = n_1 - (10-1)Y = 160 - 9 \times 4 = 160 - 36$

$\therefore n_{10} = 124 Hz$

i. The frequency of the first fork is $160\ Hz$.

ii.The frequency of the tenth fork is $124\ Hz$.

23. Given: $d = 0.5\ mm = 0.5 \times 10^{-3}\ m = 5 \times 10^{-4}\ m,\ \ D = 100\ cm = 1\ m, y_9 - y_2' = 8.835\ mm = 8.835 \times 10^{-3}\ m$

(Since both bright and dark fringes are on same side of centre of fringe pattern.)

To find: Wavelength of light (λ)

Formula: $\lambda = \frac{Wd}{D}$

Calculation: Since distance of n^{th} bright band from centre is,

$y_n=\frac{n\lambda D}{d}\Rightarrow y_9=\frac{9\lambda D}{d}$

Distance of n^{th} dark band from centre is,

$y_n'=(2n-1)\frac{\lambda D}{2\,d}$

$\therefore y_2'=(2\times 2-1)\frac{\lambda D}{2\,d}=\frac{3\lambda D}{2\,d}$

Now, $y_9-y_2'=\frac{9\lambda D}{d}-\frac{3\lambda D}{2\,d}=\frac{15\lambda D}{2\,d}$

$\therefore \lambda=\frac{2\,d(y_9-y_2')}{15D}=\frac{2\times5\times10^{-4}\times8.835\times10^{-3}}{15\times1}=\frac{8.835\times10^{-7}}{1.5}=5.89\times10^{-7}\,m=5890\overset{o}{A}$

The wavelength of light is $5890\overset{o}{A}$.

24. Given: $N=250,\ d=18\ cm,\ r=9\ cm=9\times10^{-2}\ m, I=12\ A$

To find: Magnetic moment of the coil (m)

Formula: m = NIA

Calculation: For the coil,

$A=\pi r^2$

Using formula,

$m=NI\pi r^2$

$=250\times12\times3.142\times\left(9\times10^{-2}\right)^2$

$=250\times12\times3.142\times81\times10^{-4}$

$=\{\text{antilog}[\log(250)+\log(12)+\log(3.142)+\log(81)]\}\times10^{-4}$

$=\{\text{ antilog }[2.3979+1.0792+0.4972+1.9085]\}\times10^{-4}$

$=\{\text{ antilog}[5.8828]\ \}\times10^{-4}$

$=0.7635\times10^{6}\times10^{-4}$

$\therefore$ m = **76.35 Am^2**

Magnetic moment of the coil is **76.35 Am^2**.

25. Given: $L=125mH=125\times10^{-3}H\ ,C=50\mu\,F=50\times10^{-6}\ F$

To find: Resonant frequency (f_r)

Formula: $f_r=\frac{1}{2\pi\sqrt{LC}}$

Calculation: Using formula,

$f_r=\frac{1}{2\times3.14\times\sqrt{125\times10^{-3}\times50\times10^{-6}}}$

$=\frac{1}{6.28\times\sqrt{625\times10^{-8}}}$

$=\frac{1}{6.28\times25\times10^{-4}}$

$=\frac{10^4}{6.28\times25}=\frac{400}{6.28}$

$\therefore f_r=63.69\ Hz$

The resonant frequency in the A.C. circuit is 63.69 Hz.

26. Given: $R=1.097\times10^{7}\ m^{-1},\ h\ =6.63\times10^{-34}\ J-s, c=3\times10^{8}\ m/s, n=3, e=1.6\times10^{-19}C$

To find: Energy of electron in 3$^{\text{rd}}$ orbit (E_3)

Formula: $E=\frac{-hRc}{n^2e}(\text{ in eV})$

Calculation: From Formula,

$E_3=\frac{-6.63\times10^{-34}\times1.097\times10^{7}\times3\times10^{8}}{9\times1.6\times10^{-19}}=\frac{-6.63\times1.097\times3}{9\times1.6}$

$=-\{\text{antilog}[\log(6.63)+\log(1.097)+\log(3)-\log(9)-\log(1.6)]\}$

$=-\{\text{antilog}[0.8215+0.0402+0.4771-0.9542-0.2041]\}$

$=-\{\text{antilog}[0.1805]\}$

$\therefore |E_3|=1.515\ eV$

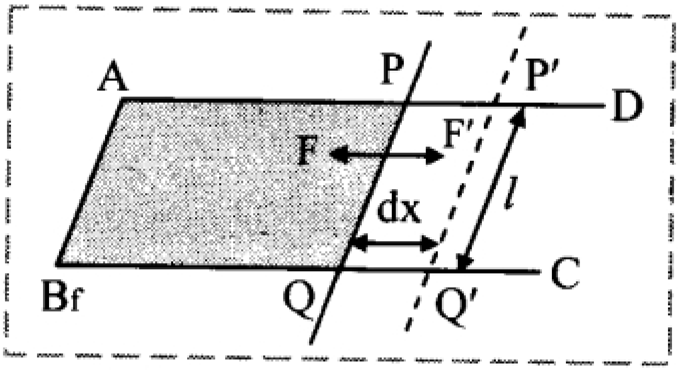
The value of energy of electron in the third Bohr orbit of hydrogen atom is 1.515 eV.

Section D

27. The extra energy of the molecules on the surface layer of a liquid is called surface energy of the liquid.

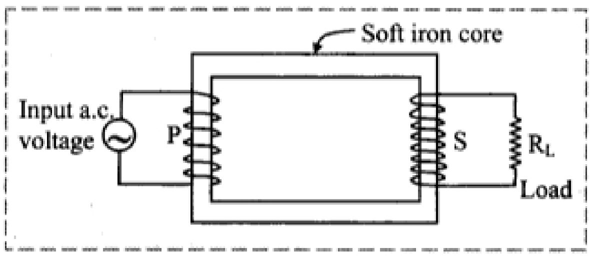
Relation between surface tension and surface energy per unit area:

1. Let $ABCD$ be a rectangular frame of wire, fitted with a movable arm PQ.



2. The frame held in horizontal position is dipped into soap solution and taken out so that a soap film APQB is formed. Due to surface tension of soap solution, a force ' F ' will act on each arm of the frame. Under the action of this force, the movable arm PQ moves towards AB.
3. Magnitude of force due to surface tension is,
   $F=2\,Tl\ldots\ldots[\because T=F/l]$
   (A factor of 2 appears because soap film has two surfaces which are in contact with wire.)
4. Let the wire PQ be pulled outwards through a small distance ' dx ' to the position $P'Q'$, by applying an external force F' isothermally, which is equal and opposite to F. Work done by this force, $dW=F'dx=2T/dx$.
5. But, $2ldx=dA=$ increase in area of two surfaces of film.
   $\therefore dW=TdA$
6. This work done in stretching the film is stored in the area dA in the form of potential energy (surface energy).
   $\therefore$ Surface energy, $E=TdA$
   $\therefore \frac{E}{dA}=T$
   Hence, surface tension = surface energy per unit area.
7. Thus, surface tension is equal to the mechanical work done per unit surface area of the liquid, which is also called as surface energy.

28. Answer the following questions:
   (i) **Principle:**
   Working of a transformer is based on the principle of mutual induction i.e., whenever the magnetic flux linked with a coil changes, an e.m.f is induced in the neighbouring coil.
   Construction:
   i. A step-up transformer consists of two sets of coils primary P and secondary S insulated from each other. The number of turns in secondary coil N_S is greater than the number of turns in primary coil N_P. The coil P is called the input coil and coil S is called the output coil.
   ii. The two coils are wound separately on a laminated soft iron core.



   (ii) Given: $l=\frac{1}{\sqrt{\pi}}\,m,\ B=4\times10^{-3}\,T$
   $e=16mV=16\times10^{-3}\,V$
   To find: Number of revolutions (f)
   Formula: $e=Bf\pi l^2$
   Calculation: From formula,
   $f=\frac{e}{B\pi l^2}=\frac{16\times10^{-3}}{4\times10^{-3}\times\pi\times\left(\frac{1}{\sqrt{\pi}}\right)^2}=4$ r.p.s.
   The number of revolutions made by rod per second is **4**.

29. Answer the following questions:

(i) i. A process in which change in pressure and volume takes place at a constant temperature is called an isothermal process or isothermal change.

ii. Adiabatic process is a process during which there is no transfer of heat from or to the system.

(ii) Given: As the gas is monatomic, $\gamma = \frac{5}{3}$

$T_2 = 2T_1 \Rightarrow \frac{T_2}{T_1} = 2$

To find: Ratio of final pressure to its initial pressure $\left(\frac{p_2}{p_1}\right)$

Formula: $p_1^{1-\gamma} T_1^{\gamma} = p_2^{1-\gamma} T_2^{\gamma}$

Calculation: From formula,

$\therefore \left(\frac{p_1}{p_2}\right)^{1-r} = \left(\frac{T_2}{T_1}\right)^{\gamma}$

$\therefore \left(\frac{p_1}{p_2}\right)^{\frac{-2}{3}} = \left(\frac{T_2}{T_1}\right)^{\frac{5}{3}} \Rightarrow \left(\frac{p_2}{p_1}\right)^{\frac{2}{3}} = \left(\frac{T_2}{T_1}\right)^{\frac{5}{3}}$

On taking cube of both sides, we get

$\therefore \left(\frac{p_2}{p_1}\right)^2 = \left(\frac{T_2}{T_1}\right)^5 = (2)^5 = 32$

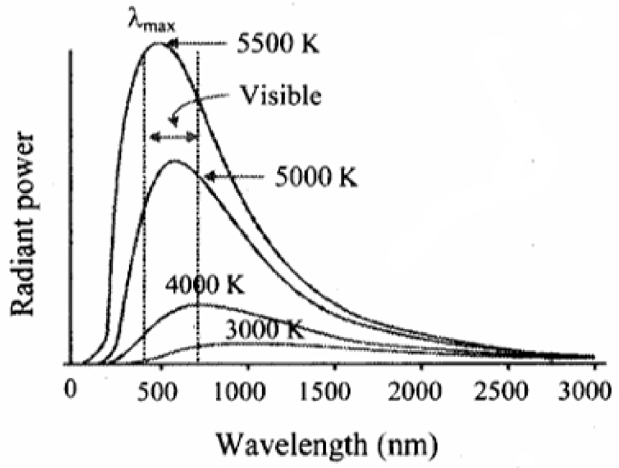
Taking square root of both sides, we get

$\therefore \frac{p_2}{p_1} = \sqrt{32} = 4\sqrt{2} = 4 \times 1.414 = 5.656$

The ratio of final pressure to its initial pressure is 5.656.

30. Answer:

(i)



Spectral distribution of blackbody radiation

(ii) Given: $R = 8320\ J/k$ mole $K, M_0 = 40$,

$T = 127^{\circ}C = 127 + 273 = 400\ K$

To find: Kinetic energy (K.E)

Formula: $K \cdot E/kg = \frac{3}{2} \frac{RT}{M_0}$

Calculation: From formula,

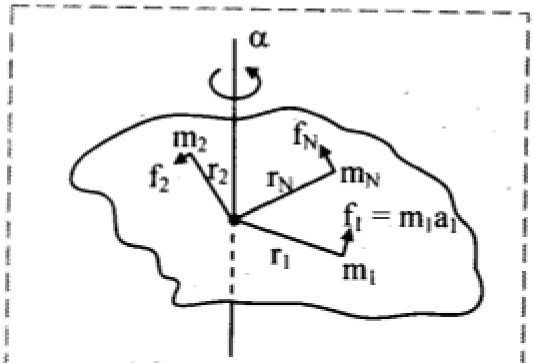
$K.E/kg = \frac{3}{2} \times \frac{8320 \times 400}{40}$

$= 1.248 \times 10^5\ J$

$\therefore$ K.E for 10 gram $= 1248J$ of Argon

The kinetic energy of 10 grams of Argon molecules at $127^{\circ}C$ is $1248\ J$.

31. i. Consider a rigid object rotating with a constant angular acceleration 'α' about an axis perpendicular to the plane of paper.



A body of N particles

ii. Let us consider the object to be consisting of N number of particles of masses $m_1, m_2, \ldots . . m_N$ at respective perpendicular distances $r_1, r_2, \ldots \ldots r_N$ from the axis of rotation.

iii. As the object rotates, all these particles perform circular motion with same angular acceleration α, but with different linear (tangential) accelerations $a_1 = r_1\alpha$, $a_2 = r_2\alpha, \ldots, a_N = r_N\alpha$, etc.

iv. Force experienced by the first particle is,

$f_1 = m_1a_1 = m_1r_1\alpha$

v. As these forces are tangential, the respective perpendicular distances from the axis are $r_1, r_2, \cdots . r_N$.

vi. Thus, the torque experienced by the first particle is of magnitude $\tau_1 = f_1r_1 = m_1r_1^2\alpha$

Similarly,$\tau_2 = m_2r_2^2\alpha, \tau_3 = m_3r_3^2\alpha \ldots . \tau_N = m_Nr_N^2\alpha$

vii. If the rotation is restricted to a single plane, directions of all these torques are the same, and along the axis.

viii. Magnitude of the resultant torque is then given by

$\tau = \tau_1 + \tau_2 + \ldots + \tau_N$

$= \left(m_1r_1^2 + m_1r_2^2 \ldots + m_Nr_N^2\right)\alpha = I\alpha$

where, $I = m_1r_1^2 + m_2r_2^2 \ldots . + m_Nr_N^2$ is the moment of inertia of the object about the given axis of rotation.

SI unit: Nm

Dimensions: $\left[M^1\ L^2\ T^{-2}\right]$