TN CLASS 12

Magnetism & magnetic effects Of current

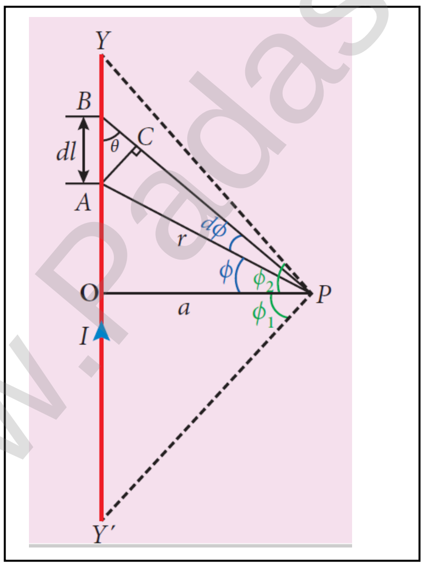
Formulae Sheet !

PRIT-EDUCATION

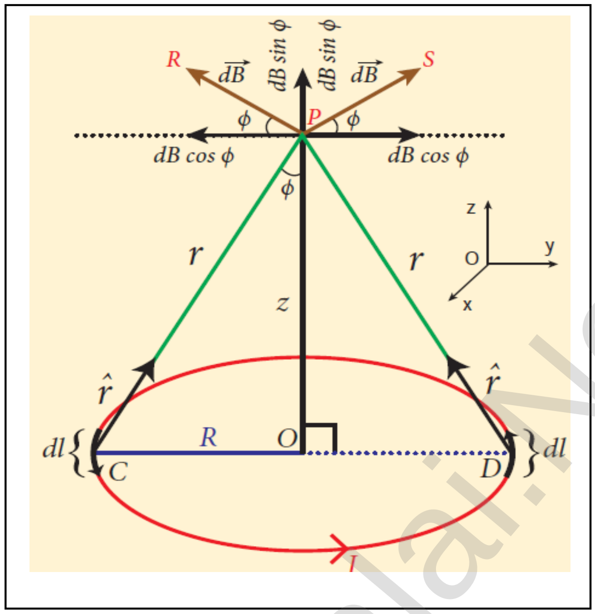
SS. PRITHVI

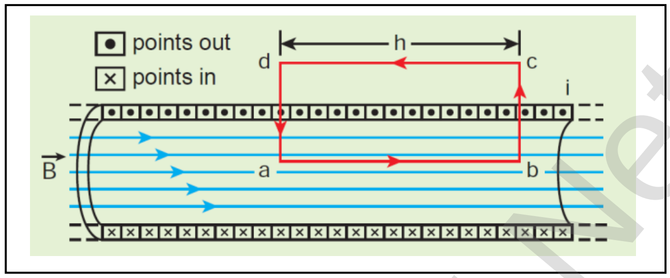
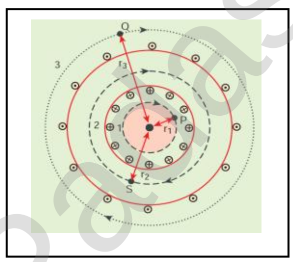
FORMULAE	EXPLANATION OF THE TERMS INVOLVED	SI UNIT
HORIZONTAL COMPONENT -Earth's magnetic field $B_H = B_E \cos I$	B_E = net Earth's magnetic field at any point on the surface of the Earth B_H = horizontal component of Earth's magnetic field **At magnetic equator** $B_H = B_E$ **At magnetic poles** $B_H = 0$	Magnetic field B = Tesla (T) CGS unit: GAUSS 1 GAUSS= 10^{-4} TESLA
VERTICAL COMPONENT - Earth's magnetic field $B_V = B_E \sin I$	B_E = net Earth's magnetic field at any point on the surface of the Earth B_H = vertical component of Earth's magnetic field **At magnetic equator** $B_V = 0$ **At magnetic poles** $B_V = B_E$	
ANGLE OF DIP $\tan I = \frac{Bh}{Bv}$	B_H=Horizontal component of magnetic field B_V=Vertical component of magnetic field tan I =angle of dip	Magnetic field B = Tesla (T) 1 GAUSS=10^{-4} TESLA
MAGNETIC DIPOLE MOMENT $\vec{p}_m = q_m \vec{d}$	Pm= magnetic dipole moment q_m= pole strength of the magnetic pole d= distance between south pole to north pole = $2l$	Ampere per metre square Am^2
MAGNETIC FIELD $\vec{B} = \frac{1}{q_m}\vec{F}$	B=magnetic field q_m=pole strength F= force experienced by the bar magnet	$NA^{-1}m^{-1}$
RATIO OF MAGNETIC LENGTH AND GEOMETRICAL LENGTH $\frac{Magnetic\ length}{Geometrical\ length} = \frac{5}{6} = 0.833$	$\frac{Magnetic\ length}{Geometrical\ length} = \frac{5}{6} = 0.833$	no unit
MAGNETIC FLUX I) FOR UNIFORM FIELD $\Phi_B = \vec{B}.\vec{A} = BA\cos\theta = B_\perp A$ • SCALAR QUANTITY • $M L^2T^{-2}A^{-1}$	ϕ_B= magnetic flux B=magnetic field A=area vector ; θ = angle between ρB and A II) FOR NON UNIFORM FIELD $\Phi_B = \int \vec{B}.d\vec{A}$	SI:weber (Wb) CGS:Maxwell 1 weber = 10^8 maxwell
MAGNETIC FLUX DENSITY $\frac{No\ of\ magnetic\ field\ lines}{Unit\ Area}$	**The magnetic flux density is defined as the number of magnetic field lines crossing per unit area kept normal to the direction of lines of force.**	$Wb\ m^{-2}$ or tesla (T)

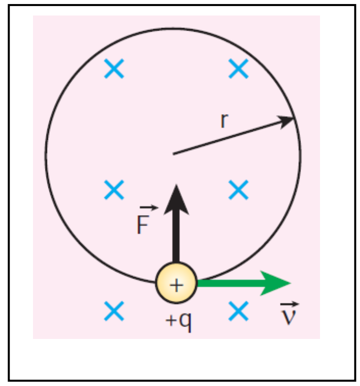
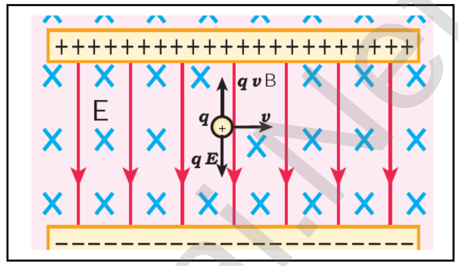
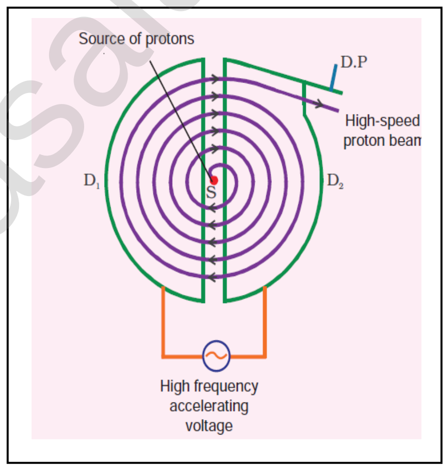
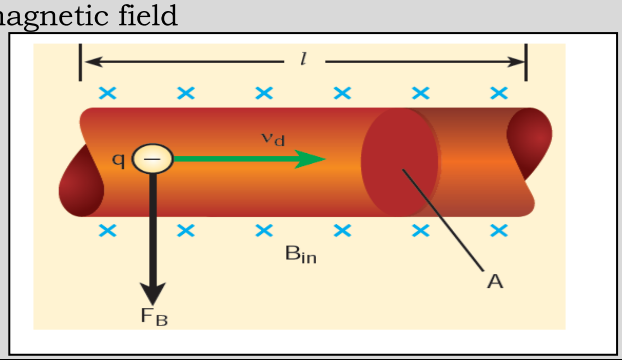
COULOMB'S INVERSE SQUARE LAW OF MAGNETISM $F = k\frac{q_{m_A} q_{m_B}}{r^2}$	F= force between two magnetic poles r = distance between two magnetic poles $k = \frac{\mu_o}{4\pi} \approx 10^{-7}\,\text{H m}^{-1}$; μ_o= absolute permeability of free space ; q_m=pole strength	force: newton (N) k: Henry per metre Hm^{-1}
MAGNETIC FIELD AT A POINT ALONG THE AXIAL LINE OF THE MAGNETIC DIPOLE (BAR MAGNET) $\vec{B}_{axial} = \frac{\mu_o}{4\pi}\frac{2}{r^3}\vec{p}_m$	Pm= magnetic dipole moment r=distance from the centre of the magnet to the point C. B=magnetic field	Magnetic field B = Tesla (T)
MAGNETIC FIELD AT A POINT ALONG THE EQUATORIAL LINE DUE TO A MAGNETIC DIPOLE (BAR MAGNET) $\vec{B}_{equatorial} = -\frac{\mu_o}{4\pi}\frac{\vec{p}_m}{r^3}$	Pm= magnetic dipole moment r=distance from the centre of the magnet to the point C. B=magnetic field	Magnetic field B = Tesla (T)
TORQUE ON A BAR MAGNET IN UNIFORM MAGNETIC FIELD $\tau = p_m B \sin\theta$	Pm= magnetic dipole moment B=magnetic field	torque: newton metre Nm
POTENTIAL ENERGY IN BAR MAGNET $U = -\vec{p}_m \cdot \vec{B}$	U=potential energy Pm= magnetic dipole moment B=magnetic field	JOULE (J)
MAGNETISING FIELD	$\vec{H}$ = magnetising field	Am^{-1}
INTENSITY OF MAGNETIZATION $\vec{M} = \frac{\text{Magnetic moment}}{\text{Volume}} = \frac{\vec{p}_m}{V}$	M= intensity of magnetization Pm= magnetic dipole moment v=volume	Am^{-1}
MAGNETIC INDUCTION OR TOTAL MAGNETIC FIELD $\vec{B} = \vec{B}_o + \vec{B}_m = \mu_o\vec{H} + \mu_o\vec{M}$ $\vec{B} = \vec{B}_o + \vec{B}_m = \mu_o(\vec{H} + \vec{M})$	definition & explanation of the terms involved:- The magnetic induction (total magnetic ρfield) inside the specimen B is equal to ρthe sum of the magnetic field Bo produced in vacuum due to the magnetising field ρand the magnetic field Bm due to the induced magnetism of the substance.	tesla
MAGNETIC SUSCEPTIBILITY $\chi_m = \frac{\lvert\vec{M}\rvert}{\lvert\vec{H}\rvert}$	X_M=magnetic susceptibility M= intensity of magnetization H=magnetising field	X_m= no unit M = Am^{-1} H = Am^{-1}

CURIE'S LAW $\chi_m \propto \frac{1}{T}$ or $\chi_m = \frac{C}{T}$	C = Curie constant T=temperature X_M=magnetic susceptibility	X_m= no unit
CURIE-WEISS LAW $\chi_m = \frac{C}{T - T_C}$	X_M=magnetic susceptibility C = Curie constant T_C= Curie temperature T=temperature	X_m= no unit
BIOT-SAVART LAW $d\vec{B} = \frac{\mu_\circ}{4\pi} \frac{I d\vec{l} \times \hat{r}}{r^2}$ ⇨ $d\vec{B} = \frac{\mu_0}{4\pi} \frac{Idl \sin\theta}{r^2} \hat{n}$	r=distance between the point P and dl *dl* =magnitude of the length element I=current; B=magnetic field	Magnetic field B = Tesla (T)
MAGNETIC FIELD DUE TO LONG STRAIGHT CONDUCTOR CARRYING CURRENT $\vec{B} = \frac{\mu_0 I}{2\pi a} \hat{n}$	μ_o= absolute permeability of free space B=magnetic field  I=current; a=dist. b/w straight conductor & the chosen point 'P'	Magnetic field B = Tesla (T)

NOTES:-

MAGNETIC FIELD PRODUCED ALONG THE AXIS OF THE CURRENT-CARRYING CIRCULAR COIL $\vec{B}=\frac{\mu_0 I}{2}\frac{R^2}{(R^2+z^2)^{3/2}}\hat{k}$ (i) If the circular coil contains *N* turns, then the magnetic field is $\vec{B}=\frac{\mu_0 NI}{2}\frac{R^2}{(R^2+z^2)^{3/2}}\hat{k}$ (ii) The magnetic field at the centre of the coil is $\vec{B}=\frac{\mu_0 NI}{2R}\hat{k}$ since $z=0$	μ_o= absolute permeability of free space B=magnetic field i=current r and z= refer from diagram 	Magnetic field B = Tesla (T)
TANGENT LAW $B_H=\frac{\mu_\circ N}{2R}\frac{I}{\tan\theta}$	N=no of turns R=radius of the coil I=current tan0^0=angle of deflection produced	Magnetic field B = Tesla (T)
MAGNETIC DIPOLE MOMENT IN CURRENT LOOP AS A MAGNETIC DIPOLE $\vec{p}_m=I\vec{A}$	*pm* =magnetic dipole moment *A* = area of the circular loop *A* = πr^2 I=current	Ampere per metre square Am^2
MAGNETIC DIPOLE MOMENT OF REVOLVING ELECTRON $\mu_L=n\times9.27\times10^{-24}\,\text{Am}^2$	μ_L=Magnetic dipole moment n=principal quantum no. (no of the orbit)	Am^2
AMPÈRE'S CIRCUITAL LAW $\oint_C \vec{B}.\vec{dl}=\mu_\circ I_{enclosed}$	B=magnetic field μ_o= absolute permeability of free space dl=closed loop I=current in enclosed area	$N/A^2 = NA^{-2}$

MAGNETIC FIELD DUE TO THE CURRENT CARRYING WIRE OF INFINITE LENGTH USING AMPÈRE'S LAW $\vec{B}=\frac{\mu_{o} I}{2\pi r}\hat{n}$	B=magnetic field μ_o= absolute permeability of free space I=current r= Radius of the Ampèrian loop	Magnetic field B = Tesla (T)
MAGNETIC FIELD DUE TO A LONG CURRENT CARRYING SOLENOID $B=\mu_0\frac{nLI}{L}=\mu_0 nI$	n=no of turns per unit length=N/L L=length of the solenoid I=current 	Magnetic field B = Tesla (T)
MAGNETIC FIELD - TOROID 1.INSIDE THE TOROID $B_S=\mu_0 nI$ 2.OPEN SPACE INTERIOR TO THE TOROID $\vec{B}_P=0$ 3.OPEN SPACE EXTERIOR TO THE TOROID $\vec{B}_Q=0$	μ_o= absolute permeability of free space $n=\frac{N}{2\pi r_2}$, n=no of turns per unit length N=total no of turns in the toroid 	Magnetic field B = Tesla (T)
LORENTZ FORCE $\vec{F}=q\left(\vec{v}\times\vec{B}\right)$ $F_m=qvB\sin\theta$	F=Lorentz force q=charge v=velocity of the charge in the magnetic field B B= magnetic filed	Newton
TESLA $1\ \mathrm{T}=\frac{1\,\mathrm{Ns}}{\mathrm{Cm}}=1\frac{\mathrm{N}}{\mathrm{Am}}=1\,\mathrm{N\,A^{-1}m^{-1}}$	The strength of the magnetic field is one tesla if a unit charge moving normal to the magnetic field with unit velocity experiences unit force.	$NA^{-1}m^{-1}$

MOTION OF A CHARGED PARTICLE IN A UNIFORM MAGNETIC FIELD TIME PERIOD: $T = \frac{2\pi m}{qB}$ ANGULAR FREQUENCY $\omega = 2\pi f = \frac{q}{m}B$	m=mass q=charge B=Magnetic field T=Time period f=frequency w=angular frequency FREQUENCY: $f = \frac{qB}{2\pi m}$ 	time: seconds (s) frequency: hertz(Hz) Angular frequency radian per seconds(rad s^{-1})
MOTION OF A CHARGED PARTICLE UNDER CROSSED ELECTRIC AND MAGNETIC FIELD (VELOCITY SELECTOR) $v_o = \frac{E}{B}$	v=velocity E=electric field B=magnetic field 	ms^{-1}
CYCLOTRON $f_{osc} = \frac{qB}{2\pi m}$ $T = \frac{2\pi m}{qB}$ $KE = \frac{1}{2}mv^2 = \frac{q^2B^2r^2}{2m}$	f=frequency T=Time period KE=kinetic energy q=charge B=magnetic field m=mass r=radius 	time: seconds (s) frequency: hertz(Hz) KE= joule(J)
FORCE ON A CURRENT CARRYING CONDUCTOR PLACED IN A MAGNETIC FIELD $\vec{F}_{total} = (I\vec{l} \times \vec{B})$ In magnitude, $F_{total} = BIl\sin\theta$	I=current l=length of straight currnt carrying conductor B=magnetic field 	Newton (N)

FORCE BETWEEN TWO LONG PARALLEL CURRENT CARRYING CONDUCTORS

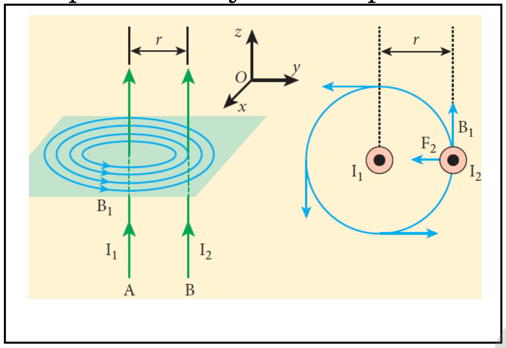
FORCE ON CONDUCTOR A

$$\frac{\vec{F}}{l} = -\frac{\mu_o I_1 I_2}{2\pi r}\hat{j}$$

FORCE ON CONDUCTOR B

$$\frac{\vec{F}}{l} = \frac{\mu_o I_1 I_2}{2\pi r}\hat{j}$$

I_1 and I_2 = electric currents passing through the conductors A and B in same direction
r = conductors separated by a distance r
μ_o= absolute permeability of free space



force = newton(N)

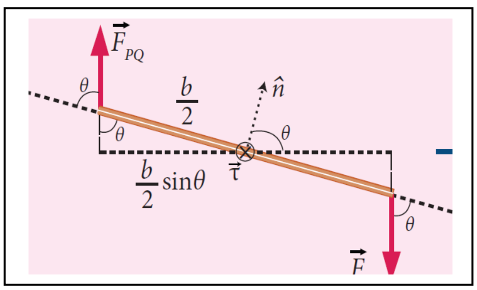
TORQUE ON A CURRENT LOOP PLACED IN A MAGNETIC FIELD

$$\tau = NIAB\sin\theta$$

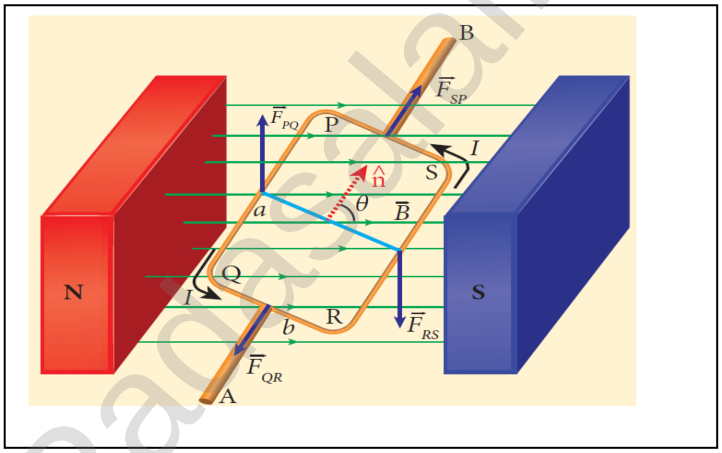
(a) When θ = 90°or the plane of the loop is parallel to B, τ is maximum.

τ_{max} = IAB

(b) When θ = 0°/180° or the plane of the loop is perpendicular to B, the τ is 0.



N=no of turns
I=Current flowing in the loop
A=Area
B=magnetic field



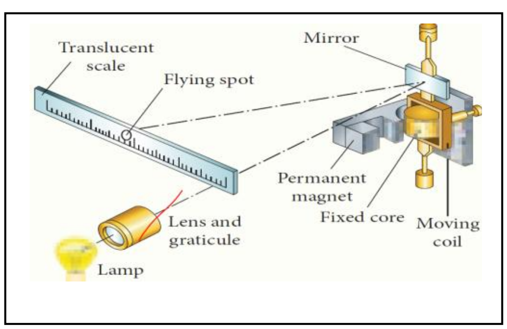
torque: newton metre Nm

CURRENT IN A MOVING COIL GALVANOMETER

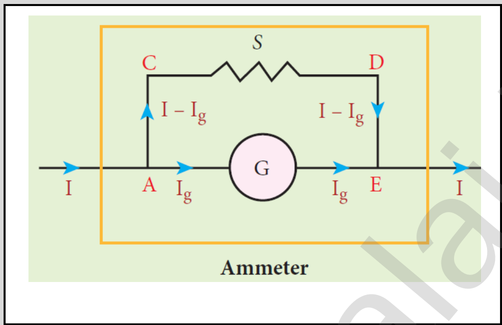
$$I = G\theta$$

I=Current

G=galvanometer constant $G = \frac{K}{NAB}$
ϑ =amount of twist

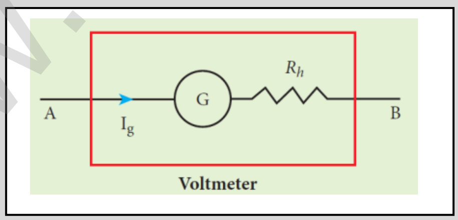


Current= Ampere (A)

VOLTAGE SENSITIVITY $V_s = \frac{\theta}{V}$ $V_s = \frac{\theta}{IR_g} = \frac{NAB}{KR_g}$ $V_s = \frac{1}{GR_g} = \frac{I_s}{R_g}$	The deflection produced per unit voltage applied across galvanometer.	rad V^{-1}
GALVANOMETER TO AN AMMETER $I_g = \frac{S}{S+R_g} I$	R_a=resistance of ammeter R_g=galvanometer's resistance S=shunt resistance through the path 	---------

In order to increase the range of an ammeter n times, the value of shunt resistance to be connected in parallel is

$$S = \frac{R_g}{n-1}$$

GALVANOMETER TO A VOLTMETER $I_g = \frac{V}{R_g + R_h}$ $\Rightarrow R_h = \frac{V}{I_g} - R_g$	R_H=Resistance value connected in series with the galvanometer I_G=Current(galvanometer) R_g=galvanometer's resistance 	---------

In order to increase the range of voltmeter *n* times the value of resistance to be connected in series with galvanometer is $R_h = (n-1)\,R_g$

With Regards,

SS PRITHVI, XII STD,

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