PS 250 Exam 3 formulas

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April 28, 2025

$$1 T = 1 \frac{N}{A m} \tag{1}$$

$$\mu_0 = 4\pi \times 10^{-7} \left[\frac{\text{T m}}{\text{A}} \right] \text{ (permeability of free space)}$$
 (2)

$$n = \text{charge density}$$
 (3)

$$1 G = 10^{-4} T \tag{4}$$

$$\vec{F} = F_E + F_B = q(\vec{E} + \vec{v} \times \vec{B}) \Longrightarrow |\vec{F}| = q(E + vB\sin\theta)$$
 (5)

this one assumes magnetic field is orthogonal to motion:

$$F_B = (\# \text{ of charges}) \left(\frac{\text{force}}{\text{charge}}\right) = (nA\ell)(qvB) = (nqv_dA)(\ell B) = I\ell B$$
 (6)

$$\vec{F}_B = q\vec{v} \times \vec{B} = I\vec{\ell} \times \vec{B} \tag{7}$$

$$\vec{\mu} = NI\vec{A}$$
 (magnetic moment) (8)

$$\vec{\tau} = NI\vec{A} \times \vec{B} = \vec{\mu} \times \vec{B} \text{ (torque)}$$
 (9)

$$U = \int \tau d\theta = -\vec{\mu} \cdot \vec{B} \quad \text{(magnetic potential energy)} \tag{10}$$

point charge:
$$B = 10^{-7} \frac{q\vec{v} \times \hat{r}}{r^2}$$
 (11)

point charge:
$$mv = |q|BR$$
 (12)

$$\oint \vec{B} \cdot d\ell = \mu_0 I_{\text{encl}} \tag{13}$$

$$\mathcal{E} = -N \frac{\mathrm{d}\Phi_B}{\mathrm{d}t} = -N \frac{\mathrm{d}(AB\cos\theta)}{\mathrm{d}t} = B\ell v \sin\theta = IR \tag{14}$$

$$\vec{B} = 10^{-7} \int \frac{I d\ell \times \hat{r}}{r^2} \tag{15}$$

$$\Phi_B = \int B \cos \theta dA = \int \vec{B} \cdot d\vec{A} = AB \cos \theta \quad [\text{Wb} = \text{T m}^2]$$
 (16)

$$\oint \vec{B} \cdot d\vec{A} = 0$$
(17)

velocity selector:
$$F_E = F_B \Longrightarrow v = \frac{E}{B}$$
 (18)

$$\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi r} \tag{19}$$

magnetic field outside a solenoid is zero

cylindrical solenoid:
$$B = \mu_0 nI = \mu_0 \frac{N}{\ell} I$$
 (20)

toroidal solenoid:
$$B = \frac{\mu_0}{2\pi} N \frac{I}{r}, r_{\min} < r < r_{\max}$$
 (21)

distance
$$r$$
 away from a radius- R wire center: $B = \frac{\mu_0}{2\pi} \begin{cases} \frac{Ir}{R^2}, r < R \\ \frac{I}{r}, r \ge R \end{cases}$ (22)

torus of current at
$$a < r < b$$
: $B = \frac{\mu_0}{2\pi} \frac{I}{r} \begin{cases} 0, r < a \\ \frac{r^2 - a^2}{b^2 - a^2}, a < r < b \\ 1, b < r \land \vec{I} \text{ into/out of page} \\ 0, b < r \land \vec{I} \text{ around loop} \end{cases}$ (23)