# Formula Sheet – 3rd Exam

## DC Circuits

Definitions of quantities:

Voltage: V (SI unit: volt)
Current: I (Amp = C/s)
Resistance: R (Ohm, Ω)

Resistance & Resistivity:

$$R = \rho \frac{L\,(length)}{A\,(area)}$$

Ohm's Law: $V = IR$

Electric Power: $P = IV = I^2 R = \frac{V^2}{R}$

Resistors in Series: $R_{total} = R_1 + R_2 + \cdots$

Resistors in Parallel: $\frac{1}{R_{toal}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$

Capacitors in series: $\frac{1}{C_{toal}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots$

Capacitors in Parallel: $C_{total} = C_1 + C_2 + \cdots$

Time constant of RC circuits: $\tau = RC$

## Magnetic Force

$\mu_0 = 4\pi \times 10^{-7}\, T \cdot m / A$

On Charge: $\vec{F} = q\vec{v} \times \vec{B}$

magnitude: $F = |q| vB \sin\theta$

On Current: $\vec{F} = L\vec{I} \times \vec{B}$

magnitude: $F = ILB \sin\theta$

Between two parallel current-carrying wires of length ***L*** and separation ***r***:

magnitude: $F = \frac{\mu_0 L I_1 I_2}{2\pi r}$

Magnetic Torque on an N-turn loop:

$\tau = NIAB \sin\theta$

## Magnetic Fields generated by currents

In an N-turn circular loop of radius R:

$B = N \frac{\mu_0 I}{2R}$ (at the center of the loop)

In an infinitely long straight wire:

$B = \frac{\mu_0 I}{2\pi r}$ (at distance ***r*** from the wire)

In an N-turn solenoid with length L:

$B = \mu_0 \left(\frac{N}{L}\right) I = \mu_0 n I$ (in the solenoid)

## Magnetic Induction

Magnetic Flux:

$\Phi_m = \vec{B} \cdot \vec{A} = BA\cos\theta$ (SI unit: Weber)

Faraday's Law of Induction:

$$V_{ind} = E = -N \frac{\Delta\Phi_m}{\Delta t}$$

Equations of Transformers:

$\frac{N_p}{V_p} = \frac{N_s}{V_s}$ or $\frac{N_p}{N_s} = \frac{V_p}{V_s}$

Electric Generator:

$V_{ind} = E = NAB\omega \sin(\omega t)$

## Inductance, *L* (SI unit: Henry):

$$V_{ind} = -N \frac{\Delta\Phi_m}{\Delta t} = -L \frac{\Delta I}{\Delta t}$$

Inductance of an N-turn solenoid with length ***l*** and cross-sectional area ***A***:

$L = \mu_0 n^2 A l$, $n = \frac{N}{l}$

Time constant of RL circuit: $\tau = \frac{L}{R}$

## Energy stored in Magnetic Fields

In an inductor:

$$U = \frac{LI^2}{2}$$

Energy density (energy per unit volume) of magnetic fields:

$$u_B = \frac{B^2}{2\mu_0}$$

## Modern Physics

Planck's Constant: $h = 6.63 \times 10^{-34}\, J \cdot s$

Energy of "one" photon:

$E = hf$ ; $f$ = frequency of light

Energy of electrons in a hydrogen-like atom:

$E = (-13.6eV)\frac{Z^2}{n^2}$ ; $1eV = 1.6 \times 10^{-19}\, J$ ;

Z = Atomic Number

Quantum #'s: given the principle quantum # = $n$

$l = 0, 1, \ldots, n-1$; $m_l = -l, -l+1, \ldots, 0, \ldots, l-1, l$

$m_s = \pm 1/2$