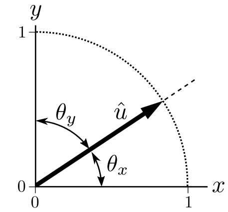
UNIVERSITY PHYSICS 2

MADISON AREA TECHNICAL COLLEGE

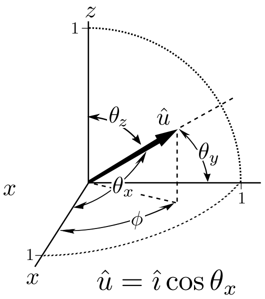
Math

$$\vec{A} = \begin{bmatrix} A_x \\ A_y \\ A_z \end{bmatrix} = A_x\hat{\imath} + A_y\hat{\jmath} + A_z\hat{k} = A\hat{u} \qquad \hat{u} = \frac{\vec{A}}{A} \qquad c\vec{A} + d\vec{B} = \begin{bmatrix} cA_x + dB_x \\ cA_y + dB_y \\ cA_z + dB_z \end{bmatrix}$$



$$\sin\theta_x = \cos\theta_y$$

$$\hat{u} = \hat{\imath}\cos\theta_x + \hat{\jmath}\sin\theta_x$$

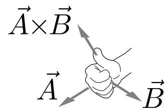


$$\hat{u} = \hat{\imath}\cos\theta_x + \hat{\jmath}\cos\theta_y + \hat{k}\cos\theta_z$$

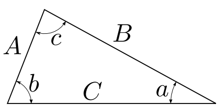
$$\vec{A}\cdot\vec{B} = A_xB_x + A_yB_y + A_zB_z = AB\cos\theta$$

$$ax^2 + bx + c = 0$$
$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$\vec{A}\times\vec{B} = (AB\sin\theta)\,\hat{u}_\perp$$



$$\vec{A}\times\vec{B} = (A_yB_z - A_zB_y)\,\hat{\imath} + (A_zB_x - A_xB_z)\,\hat{\jmath} + (A_xB_y - A_yB_x)\,\hat{k}$$



$$C^2 = A^2 + B^2 - 2AB\cos c$$
$$\frac{A}{\sin a} = \frac{B}{\sin b} = \frac{C}{\sin c}$$

$$\cos 2\theta = \cos^2\theta - \sin^2\theta$$
$$\sin 2\theta = 2\sin\theta\cos\theta$$
$$\cos^2\theta + \sin^2\theta = 1$$

useful approximations:

if $|x| \ll 1$ then $(1+x)^\alpha \approx 1 + \alpha x$

if $\theta \ll 1$ then $\sin\theta \approx \theta$, $\tan\theta \approx \theta$, $\cos\theta \approx 1$

Physics 1

$$\vec{F}_{\text{net}} = m\vec{a} = \frac{d\vec{p}}{dt} \qquad \vec{F}_G = m\vec{g} \qquad K = \tfrac{1}{2}mv^2 \qquad W = \vec{F}\cdot\vec{s} \qquad F_{\text{centrip}} = m\omega^2 r$$

$$\vec{F}_{12} = -\vec{F}_{21} \qquad \vec{\tau} = \vec{r}\times\vec{F} \qquad \vec{r}(t) = x(t)\hat{\imath} + y(t)\hat{\jmath} + z(t)\hat{k} \qquad \vec{v} = \frac{d}{dt}\vec{r}(t) \qquad \vec{a} = \frac{d}{dt}\vec{v}(t)$$

Electrostatics

$$\vec{F} = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r^2}\hat{r} \qquad k = \frac{1}{4\pi\epsilon_0} \qquad \vec{F} = q\vec{E} \qquad \vec{E} = \frac{1}{4\pi\epsilon_0}\frac{q}{r^2}\hat{r} \qquad \vec{E} = \frac{1}{4\pi\epsilon_0}\frac{2\lambda}{r}\hat{r} \qquad \vec{E} = \frac{\sigma}{2\epsilon_0}\hat{n} \qquad \vec{E} = \frac{\sigma}{\epsilon_0}\hat{n}$$

$$\vec{p} = q\vec{s} \qquad \Phi_e = \vec{E}\cdot\vec{A} \qquad \oint \vec{E}\cdot d\vec{A} = \frac{Q_{\text{in}}}{\epsilon_0} \qquad V = \frac{1}{4\pi\epsilon_0}\frac{q}{r} \qquad U = qV$$

$$\vec{\tau} = \vec{p}\times\vec{E}$$

$$\vec{E}_{\text{dp}} = \frac{1}{4\pi\epsilon_0}\frac{2\vec{p}}{r^3} \qquad E_s = -\frac{dV}{ds} \qquad \Delta V = -\int_i^f E_s\,ds$$

$$C = \frac{Q}{V_C} \qquad C = \kappa C_0 \qquad C_{\text{pp}} = \epsilon_0\frac{A}{d}$$

$$U_{\text{dp}} = -\vec{p}\cdot\vec{E} \qquad U = \frac{QV_C}{2} = \frac{CV_C^2}{2} = \frac{Q^2}{2C} \qquad u_e = \tfrac{1}{2}\kappa\epsilon_0E^2$$

Circuits

$$I = \frac{dq}{dt} \qquad J = \frac{I}{A} \qquad J = \sigma E \qquad \sigma = \rho^{-1} \qquad R = \frac{\rho L}{A}$$

$$V = IR \qquad I = n_e eAv_d \qquad P = IV = \frac{V^2}{R} = I^2R$$

$$\tau = RC$$

$$X(t) = X_0e^{-t/\tau}$$

$$X(t) = X_0\left(1 - e^{-t/\tau}\right)$$

around a circuit loop: $\sum \Delta V_i = 0$

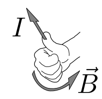
at a circuit junction: $\sum I_{\text{in}} = \sum I_{\text{out}}$

Series	Parallel
$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots$	$C_T = C_1 + C_2 + C_3 + \cdots$
$V_T = V_1 + V_2 + V_3 + \cdots$	$V_1 = V_2 = V_3 = \cdots$
$I_1 = I_2 = I_3 = \cdots$	$I_T = I_1 + I_2 + I_3 + \cdots$
$R_T = R_1 + R_2 + R_3 + \cdots$	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots$

Magnetism

$\vec{F} = q\vec{v}\times\vec{B}$ $\quad \vec{F} = I\vec{\ell}\times\vec{B}$ $\quad \vec{\mu} = NIA\hat{n}$ $\quad \vec{\tau} = \vec{\mu}\times\vec{B}$ $\quad r_{\text{cyc}} = \dfrac{mv}{qB}$

$\vec{B} = \dfrac{\mu_0}{4\pi}\dfrac{q\vec{v}\times\hat{r}}{r^2}$ $\quad d\vec{B} = \dfrac{\mu_0}{4\pi}\dfrac{Id\vec{\ell}\times\hat{r}}{r^2}$ $\quad B_{\text{wire}} = \dfrac{\mu_0 I}{2\pi r}$



$B_{\text{loop}} = \dfrac{\mu_0 I}{2R}$ $\quad B_{\text{sol}} = \dfrac{\mu_0 NI}{\ell}$ $\quad F = \dfrac{\mu_0 I_1 I_2}{2\pi r}\ell$ $\quad \oint \vec{B}\cdot d\vec{\ell} = \mu_0 I_{\text{thu}}$

Induction

$\mathcal{E} = v\ell B$ $\quad \mathcal{E} = NBA\omega\sin(\omega t)$ $\quad \Phi_{\text{m}} = \int_{\text{area}} \vec{B}\cdot d\vec{A}$ $\quad \mathcal{E}_1 = -M\dfrac{dI_2}{dt}$

$M = \dfrac{N_2\Phi_2}{I_1} = \dfrac{N_1\Phi_1}{I_2}$ $\quad L = N\dfrac{\Phi_{\text{m}}}{I}$ $\quad \mathcal{E} = -L\dfrac{dI}{dt}$

$\mathcal{E} = \oint \vec{E}\cdot d\vec{\ell} = -\dfrac{d\Phi_{\text{m}}}{dt}$ $\quad L_{\text{sol}} = \dfrac{\mu_0 N^2 A}{\ell}$ $\quad U_L = \frac{1}{2}LI^2$ $\quad u_B = \dfrac{1}{2\mu_0}B^2$

$V_L(t) = V_0 e^{-t/\tau}$ $\quad \tau = L/R$ $\quad V_L(t) = V_0\cos(\omega t + \phi)$ $\quad \omega = \dfrac{1}{\sqrt{LC}}$

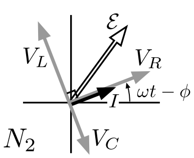
AC Circuits

$\mathcal{E}(t) = \mathcal{E}_0\cos\omega t$ $\quad i(t) = I\cos(\omega t - \phi)$ $\quad X_C = 1/\omega C$ $\quad X_L = \omega L$

$\omega = 2\pi f = \dfrac{2\pi}{T}$ $\quad V_R = IR$ $\quad V_C = IX_C$ $\quad V_L = IX_L$ $\quad \mathcal{E}_0 = IZ$

$V_{\text{rms}} = \dfrac{V}{\sqrt{2}}$ $\quad I_{\text{rms}} = \dfrac{I}{\sqrt{2}}$ $\quad P_R = I_{\text{rms}}V_{\text{rms}}$ $\quad \mathcal{E}_0^2 = V_R^2 + (V_L - V_C)^2$

$\phi = \tan^{-1}\dfrac{X_L - X_C}{R}$ $\quad Z = \sqrt{R^2 + (X_L - X_C)^2}$



$\omega_c = \dfrac{1}{RC}$ $\quad \omega_0 = \dfrac{1}{\sqrt{LC}}$ $\quad P = I_{\text{rms}}\mathcal{E}_{\text{rms}}\cos\phi$ $\quad \dfrac{V_2}{V_1} = \dfrac{N_2}{N_1}$

EM Waves

$\oint \vec{E}\cdot d\vec{A} = \dfrac{Q_{\text{in}}}{\epsilon_0}$ $\quad \oint \vec{B}\cdot d\vec{A} = 0$ $\quad \vec{F} = q(\vec{E} + \vec{v}\times\vec{B})$

$\oint \vec{E}\cdot d\vec{\ell} = -\dfrac{d\Phi_{\text{m}}}{dt}$ $\quad \oint \vec{B}\cdot d\vec{\ell} = \mu_0 I_{\text{thru}} + \epsilon_0\mu_0\dfrac{d\Phi_{\text{e}}}{dt}$ $\quad c = f\lambda$

$c^2 = \dfrac{1}{\epsilon_0\mu_0}$ $\quad \vec{S} = \dfrac{1}{\mu_0}\vec{E}\times\vec{B}$ $\quad \dfrac{E_0}{B_0} = c$

$I = S_{\text{ave}} = \dfrac{E_0 B_0}{2\mu_0}$ $\quad I = \dfrac{P_{\text{source}}}{4\pi r^2}$ $\quad I = I_0\cos^2\theta$

Optics

$\dfrac{1}{d_o} + \dfrac{1}{d_i} = \dfrac{1}{f}$ $\quad f = \dfrac{R}{2}$ $\quad n = \dfrac{c}{v}$ $\quad m = -\dfrac{d_i}{d_o} = \dfrac{h_i}{h_o}$ $\quad \sin\theta_c = \dfrac{n_2}{n_1}$

$\dfrac{n_1}{n_2} = \dfrac{v_2}{v_1} = \dfrac{\lambda_2}{\lambda_1} = \dfrac{\sin\theta_2}{\sin\theta_1}$ $\quad M = \dfrac{\theta_i}{\theta_o}$ $\quad \dfrac{1}{f} = (n-1)\left(\dfrac{1}{R_1} - \dfrac{1}{R_2}\right)$

$d\sin\theta = m\lambda$ $\quad a\sin\theta = m\lambda$ $\quad I = I_0\left(\dfrac{\sin(\phi/2)}{\phi/2}\right)^2$ $\quad \phi = 2\pi\dfrac{a\sin\theta}{\lambda}$

$D\sin\theta = 1.22\lambda$

Constants

Coulomb constant	k	8.99×10^{9} N m^2/C^2
electron mass	m_e	9.11×10^{-31} kg
fundamental charge	e	1.60×10^{-19} C
permittivity of free space	ϵ_0	8.854×10^{-12} F/m
permeability of free space	μ_0	$4\pi\times 10^{-7}$ T·m/A
speed of light	c	3.00×10^{8} m/s

Symbols and Units

area	A	m^2
acceleration	a	m/s^2
slit width	a	m
magnetic field	B	T
capacitance	C	F
distance	d	m
slit separation	d	m
diameter	D	m
slit width	D	m
electric field	E	V/m, N/C
emf	$\mathcal{E}$	V
frequency	f	1/s, Hz
focal length	f	m
force	F	N
image, object size	h_i, h_o	m
current	I, i	A, C/s
intensity	I	W /m^2
current density	J	C/s/m^2
Coulomb constant	k	N m^2/C^2
kinetic energy	K	J
length	ℓ, l	m
inductance	L	H, T·m^2/A
mass	m	kg
order	m	(none)
lateral magnification	m	(none)
mutual inductance	M	H, T·m^2/A
angular magnification	M	(none)
number	N	(none)
unit normal vector	$\hat{n}$	(none)
number density	n	m^{-3}
refractive index	n	(none)
electric dipole moment	p	C·m
power	P	W, J/s
electric charge	q, Q	C
unit radial vector	$\hat{r}$	(none)
distance or radius	r, R	m
resistance	R	Ω
path length	s	m
image, object distance	d_i, d_o	m
Poynting vector	S	W/m^2
time	t	s
potential energy	U	J
energy density	u	J/m^3
unit vector	$\hat{u}$	(none)
velocity	v	m/s
electric potential	V	V
work	W	J, N·m
reactance	X	Ω
x,y-axis coordinate	x, y	m
impedance	Z	Ω
angle	θ	radians
dielectric constant	κ	(none)
line charge density	λ	C/m
wavelength	λ	m
magnetic moment	μ	A · m^2
resistivity	ρ	Ω·m
conductivity	σ	(Ω·m)$^{-1}$
surface charge density	σ	C/m^2
torque	τ	N · m
time constant	τ	s
phase angle	ϕ	radians
electric field flux	Φ_{e}	N·m^2/C
magnetic field flux	Φ_{m}	Wb, T· m^2
angular frequency	ω	rad/s