Oscilations

Simple Harmonic Motion

$T = \frac{1}{f}$

$x(t) = x_m cos(\omega t + \phi)$

$\omega = \frac{2\pi}{T} = 2\pi f$

$v(t) = -\omega x_m sin(\omega t + \phi)$

$a(t) = -\omega^2 x_m cos(\omega t + \phi)$

$> F = ma = m\left(-\omega^2 x\right)$

$> F = -kx = -\left(m\omega^2\right)x$

$\omega = \sqrt{\frac{k}{m}}$

$T = 2\pi\sqrt{\frac{m}{k}}$

k: constante da mola

Energy in SHM

$U(t) = \frac{1}{2}kx^2$

$K(t) = \frac{1}{2}mv^2$

$E = U + K = \frac{1}{2}kx_m^2$

Damped SHM

b: damping constante

$F_d = -bv$

$x(t) = x_m e^{-\frac{bt}{2m}} cos(\omega' t + \phi)$

$\omega' = \sqrt{\frac{k}{m} - \frac{b^2}{4m^2}}$

if b small $\omega' \approx \omega$

$E(t) \approx \frac{1}{2}kx_m^2 e^{-\frac{bt}{m}}$

Waves

Transverse Waves

Luz vacuo: $c = 299792458$m/s

k: numero de onda

λ : comprimento de onda

$y(x,t) = y_m sin(kx - \omega t)$

$k = \frac{2\pi}{\lambda}$

$> \omega = \frac{2\pi}{T}$

$> f = \frac{1}{T} = \frac{\omega}{2\pi}$

$v = \frac{\omega}{k} = \frac{\lambda}{T} = \lambda f$

EnergPow Wave String

$> dK = \frac{1}{2}dm\,u^2$

$P_{avg} = \frac{1}{2}\mu v\omega^2 y_m^2$

Wave Equation

$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$

Interference of Waves

$y'(x,t) = y_1(x,t) + y_2(x,t)$

$y'(x,t) = \left[2y_m cos\left(\frac{1}{2}\phi\right)\right] sin\left(kx - \omega t + \frac{1}{2}\phi\right)$

StandingWavesResonance

$y'(x,t) = [2y_m sin(kx)]cos(\omega t)$

$f = \frac{v}{\lambda} = n\frac{v}{2L}$ n=1,2,3...

Waves 2

Speed of Sound

$v = \sqrt{\frac{B}{\rho}}$

v: som no ar a 20 o C é 343 m/s

Traveling Sound Waves

$s(x,t) = s_m cos(kx - \omega t)$

$\Delta p(x,t) = \Delta p_m sin(kx - \omega t)$

$\Delta p = (v\rho\omega)s_m$

Intensity and Sound Level

$> I = \frac{P}{A}$

$I = \frac{1}{2}\rho v\omega^2 s_m^2$

distance $I = \frac{P_s}{4\pi r^2}$

decibel $\beta = (10dB)log\left(\frac{I}{I_0}\right)$

$I_0 = 10^{-12}W/m^2$

SourcesMusic

dois lados $f = \frac{v}{\lambda} = \frac{nv}{2L}$

um lado $f = \frac{v}{\lambda} = \frac{nv}{4L}$

Beats

$f_{beat} = f_1 - f_2$

Doppler Effect

Detector: aprox + , afast -

Source: aprox - , afast +

$f' = \frac{v \pm v_D}{v \pm v_S}$

SupersonicSpeedShockWave

$sin\theta = \frac{vt}{v_s t} = \frac{v}{v_s}$

Electric Charge

Coulomb's Law

$> i = \frac{dq}{dt}$

$\vec{F} = k\frac{q_1 q_2}{r^2}\hat{r}$

$k = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9\ N \cdot m^2/C^2$

$\varepsilon_0 = 8.85 \times 10^{-12}\ C^2/N \cdot m^2$

Charge is Quantized

$q = ne,\ n = \pm 1, \pm 2, \pm 3 \ldots$

$e = 1.602 \times 10^{-19}C$

Electric Fields

$\vec{E} = \frac{\vec{F}}{q_0}\ (N/C)$

due to a Point

$\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{|q|}{r^2}\hat{r}$

$\vec{E} = \frac{\vec{F_0}}{q_0} = \frac{\vec{F_{01}}}{q_0} + \frac{\vec{F_{02}}}{q_0} + \cdots = \vec{E}_1 + \vec{E}_2 + \ldots$

due to Electric Dipole

$\vec{p} = qd$

if $z >> d$

$E = \frac{1}{2\pi\varepsilon_0}\frac{p}{z^3}$

Dipole in eletric field

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

$U = -\vec{p} \cdot \vec{E}$

Gauss's Law

Eletric FLux

$\Phi = \oint \vec{E} \cdot d\vec{A}$

Gauss's Law

$\varepsilon_0 \Phi = q_{enc}$

σ : charge per unit area

$E = \frac{\sigma}{\varepsilon_0}$ ChargedIsolConducExternEF

λ : linear charge density

$E = \frac{\lambda}{2\pi\varepsilon_0 r}$ Cylindrical Line

$E = \frac{\sigma}{2\varepsilon_0}$ Planar Non-conducting Sheet

$E = \frac{\sigma}{\varepsilon_0}$ Planar Two Conducting Plates

Spherical

Shell

$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2} : r \geq raioShell$

$E = 0 : r < raioShell$

Sphere

$E = \frac{1}{4\pi\varepsilon_0}\frac{q}{R^3}r$

Electric Potential

$V = -\frac{W}{q}$

$V = \frac{-W_\infty}{q_0} = \frac{U}{q_0}$ (volt=joule per coulomb)

Units

$1N/C = \left(1\frac{N}{C}\right)\left(\frac{1V \cdot C}{1J}\right)\left(\frac{1J}{1N \cdot m}\right) = 1V/m$; $1eV = e(1V) = \left(1.60 \times 10^{-19}C\right)(1J/C) = 1.60 \times 10^{-19}J$

Work done by Applied Force

$\Delta K = K_f - K_i = W_{appF} + W_{efF}$

$W_{appF} = -W_{efF}$ if stationary before and after move $K_f = K_i = 0$

$\Delta U = U_f - U_i = W_{appF}$

$\Delta U = U_f - U_i = W_{appF}$

Equipotential Surfaces

$V_f - V_i = -\int_i^f \vec{E} \cdot d\vec{s}$

$V = -\int_i^f \vec{E} \cdot d\vec{s}$ se $V_i = 0$ ex:infinity

Potential due to Point Charge

$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$

Potential due to GroupOfPointCharges

Superposition principle, the sum of the values, unlike electric fields that was a sum of vectors

$V = \sum_{i=1}^{n}(V_i) = \frac{1}{4\pi\varepsilon_0}\sum_{i=1}^{n}\left(\frac{q_i}{r_i}\right)$

Potential due to Electric Dipole

$\vec{p} = qd$

if $r >> d$

$V = \frac{1}{4\pi\varepsilon_0}\frac{p\,cos\theta}{r^2}$

Potential due to ContinousDistribution

$> V = \frac{1}{4\pi\varepsilon_0}\int\frac{dq}{r} = \frac{1}{4\pi\varepsilon_0}\int\frac{\lambda dx}{r}$

Calculating field from potential

$> E_s = -\frac{\partial V}{\partial s}$

$> E_x = -\frac{\partial V}{\partial x}$; $E_y = -\frac{\partial V}{\partial y}$; $E_z = -\frac{\partial V}{\partial z}$

$> E = -\frac{\Delta V}{\Delta s}$

ElectricPotentialEnergy SystemPointCharges

$U = W = q_2 V = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r}$

Capacitance

$q = CV$ 1 farad (1 F) = 1 coulomb per volt (1 C/V)

Calculating Capacitance

$C = \frac{\varepsilon_0 A}{d}$: placas paralelas

$C = 2\pi\varepsilon_0\frac{L}{ln\left(\frac{b}{a}\right)}$: cilindros

$C = 4\pi\varepsilon_0\frac{ab}{b-a}$: esferas

$C = 4\pi\varepsilon_0 R$: esfera isolada

Capacitors

$C_{eq} = \sum_{j=1}^{n}\left(C_j\right)$: in paralel, mesmo V separa q

$\frac{1}{C_{eq}} = \sum_{j=1}^{n}\left(\frac{1}{C_j}\right)$: in series, mesmo q separa V

Energy Stored Electric Field

$U = \frac{q^2}{2C} = \frac{1}{2}CV^2$

$u = \frac{1}{2}\varepsilon_0 E^2$: energy density

Capacitor with a Dieletric

If dieletric replace ε with $k\varepsilon$, k dieletric constant

$\varepsilon_0\oint k\vec{E} \cdot d\vec{A} = q$: GaussLaw w/ Dialetric

Current And Resistance

Electric Current

$i = \frac{dq}{dt}$ 1ampere(1A)=1 coulomb per second(1C/s)

Current Density

$i = \int \vec{J} \cdot d\vec{A}$

$\vec{J} = (ne)\vec{v_e}$: $\vec{v_e}$ drift speed

Resistance and Resistivity

$R = \frac{V}{i}$: 1 ohm (1Ω) = 1 volt per ampere = 1 V/A

$\rho = \frac{1}{\sigma} = \frac{\vec{E}}{\vec{J}}$: ρ Resistivity, σ conductivity

$R = \rho\frac{L}{A}$

$\rho - \rho_0 = \rho_0\alpha(T - T_0)$

Power Potencia

$P = iV$: rate eletrical energy transfer

$P = i^2 R = \frac{V^2}{R}$: resistive dissipation

1 volt-ampere $1V \cdot A = \left(1\frac{J}{C}\right)\left(1\frac{C}{s}\right) = 1\frac{J}{s} = 1W$ 1 watt

$P = \frac{W}{\Delta t}$

Circuitos Eletricos

Amperimetro serie, Voltimetro paralelo

Resistencias

$R_{eq} = \sum_{j=1}^{n} \left(R_j\right)$: in series, mesmo i separa V

$\frac{1}{R_{eq}} = \sum_{j=1}^{n} \left(\frac{1}{R_j}\right)$: in paralel, mesmo V separa i

Circuitos RC

Reistencia Capacitor em serie

$RC = \tau$: constante de tempo capacitiva

$q = C\xi\left(1-e^{-\frac{t}{RC}}\right)$: carga

$i = \left(\frac{\xi}{R}\right)e^{-\frac{t}{RC}}$: carga

$q = q_0 e^{-\frac{t}{RC}}$: descarga

$i = -\left(\frac{q_0}{RC}\right)e^{-\frac{t}{RC}}$: descarga

Campo Magnetico

$\vec{F_B} = q\left(\vec{v}\times\vec{B}\right)$

$F_B = |q| v B sen(\phi)$

Regra mao direita(pistola): polegar F_B, indicador v, palma B

Unidade campo magnetico: Tesla(T) = $T = \frac{Wb}{m^2} = \frac{N}{C\cdot(m/s)} = \frac{N}{A\cdot m}$

(Wb é weber) (Unidade cgs é um gauss(G) 1T=10^4G)

ForcaParticCarregMovCircular

$|q| v B = \frac{mv^2}{r}$

$r = \frac{mv}{|q|B}$

$\omega = \frac{v}{r} = \frac{|q|B}{m}$

$f = \frac{1}{T} = \frac{\omega}{2\pi} = \frac{|q|B}{2\pi m}$

MovParticCarregCampoElecMag

> $\vec{F} = q\vec{E} + q\left(\vec{v}\times\vec{B}\right)$

SelectorVelocidade

> Se $F_B = F_E$: $v = \frac{E}{B}$ mov reto

CMag devido CorrenteRectilinea

Regra mao direita: polegar corrente eletrica, dedos dobram no sentido de B ; Pontos(sairPag, cima) sao dados pela ponta dos dedos, do lado q aparecem primeiro dps de dar volta fio, outro lado cruz(entrarPag, baixo) ; Fio empurrado po lado do campo contario ao q esta a receber

CMag Exerc Forca Corrent

$\vec{F_B} = q\left(\vec{v}\times\vec{B}\right)nAL$ n numero de cargas, A area, L comprimento

$\vec{F} = i\vec{L}\times\vec{B}$ força sobre um fio retilineo

$\vec{F} = i\int_a^b d\vec{L}\times\vec{B}$ força sobre um fio

CMag Exerc MomentForca Espira

$\tau = iABsin(\theta)$, A area , N num espiras, θ angl normalA e B (max qd espira paralelo campo)

$\vec{\tau} = Ni\vec{A}\times\vec{B}$, A intensidade area, sentido normalDeA

Regra mao direita espiras (achar sentido de A): Dedos curvam sentido da corrente, polegar sentido de A

Momento Dipolar Magnetico

$\vec{\mu} = Ni\vec{A}$

$\vec{\tau} = \vec{\mu}\times\vec{B}$ momento de Forca

$U(\theta) = -\vec{\mu}\times\vec{B}$ energia potencial magentica

CMag Prodz por Dipolo

$\vec{B}(z) \cong \frac{\mu_0}{2\pi}\frac{\vec{\mu}}{z^3}$

com $\mu_0 = 4\pi\times10^{-7}\ T\cdot m/A$

MagneticFields dueTo Currents

Permeability constant(constante magnetica): $\mu_0 = 4\pi\times10^{-7}\ T\cdot m/A \approx 1.26\times10^{-6}\ T\cdot m/A$

$d\vec{B} = \frac{\mu_0}{4\pi}\frac{i\,d\vec{s}\times\vec{r}}{r^2}$ ds = dL (comprimento)

$B = \frac{\mu_0 i}{2\pi R}$ long straight wire , R distancia

$B = \frac{\mu_0 i}{4\pi R}$ semi-infinite straight wire

$B = \frac{\mu_0 i\phi}{4\pi R}$ center of circular arc, ϕ arc angle

$B = \frac{\mu_0 i}{2R}$ full circle

Force between parallel wires

$F_{ba} = i_b L B_a \sin(90^\circ) = \frac{\mu_0 L i_a i_b}{2\pi d}$

L length, d distance , mesmo sentido atrai

Amperes Law

$\oint\vec{B}\cdot d\vec{s} = \mu_0 i_{envolvida}$ mao aberta dedos ao longo do loop, pra frente do polegar positivo, atras negativo

$B = \frac{\mu_0 i}{2\pi r}$ ouside straight wire

$B = \left(\frac{\mu_0 i}{2\pi R^2}\right)r$ inside striagh wire

Solenoid and Toroids

$B = \mu_0 i n$ idela solenoid, n num turns

$B = \frac{\mu_0 i N}{2\pi}\frac{1}{r}$ toroid, r dist centro

CurrCarryingCoil as magDipole

$\vec{B}(z) = \frac{\mu_0}{2\pi}\frac{\vec{\mu}}{z^3}$ z dist centro bob

Induction Inductance

Faraday Law of Induction

$\Phi_B = \int\vec{B}\cdot d\vec{A}$ magnetic flux pela area A

$\Phi_B = BA$ B prependicular A

$\xi = -N\frac{d\Phi_b}{dt}$ faraday law, N num de espiras

Inducted Eletric Fields

$\xi = \oint\vec{E}\cdot d\vec{s}$

$\oint\vec{E}\cdot d\vec{s} = -N\frac{d\Phi_b}{dt}$

Inductance

$L = \frac{N\Phi_B}{i}$ $\left(T\,m^2/A\right)$ inductance

$\frac{L}{l} = \mu_0 n^2 A$ inductance of Solenoid, A area, l lenght, n num turns

$\xi_L = -L\frac{di}{dt}$ self-induced eletromotriz

RL Circuits

$i = \frac{\xi}{R}\left(1-e^{-\frac{t}{\tau_L}}\right)$ rise of current

$i = \frac{\xi}{R}e^{-\frac{t}{\tau_L}} = i_0 e^{-\frac{t}{\tau_L}}$ decay of current

$\tau_L = \frac{L}{R}$ time constant

EnergyStored MagField

$U_B = \frac{1}{2}Li^2$ magnetic energy

EnergyDensity MagField

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

Mutual Induction

$\xi_2 = -M\frac{di_1}{dt}$

$\xi_1 = -M\frac{di_2}{dt}$

M medida em henries, inductancia mutua

Corrente Alternada

Potencia

$i_{rms} = \frac{i}{\sqrt{2}}$ corrente rms

$V_{rms} = \frac{V}{\sqrt{2}}$ tensao rms

$\xi_{rms} = \frac{\xi}{\sqrt{2}}$ forca eletomotriz rms

$P_{med} = i_{rms}^2 R = \xi_{rms} i_{rms} cos(\phi)$ potencia media

Transformadores

$V_s = V_p\frac{N_s}{N_p}$ transformacao tensao

$I_s = I_p\frac{N_p}{N_s}$ transformacao corrente

$R_{eq} = \left(\frac{N_p}{N_s}\right)^2 R_s$

MaxwellEquations

$\Phi_B = \oint\vec{B}\cdot d\vec{A} = 0$ gauss mag field ; $\oint\vec{B}\cdot d\vec{s} = \mu_0\varepsilon_0\frac{d\Phi_E}{dt}$ maxwell law infuction ; $\oint\vec{B}\cdot d\vec{s} = \mu_0\varepsilon_0\frac{d\Phi_E}{dt} + \mu_0 i_{enc}$ ampere-maxwell law

Electrons

$\vec{\mu_s} = -\frac{e}{m}\vec{S}$ spin angular momentum, S spin ;; $e = 1.60\times10^{-19}C$; $m = 9.11\times10^{-31}kg$; ...

Electromagnetic Waves

$E = E_m sin(kx-\omega t)$ electric field

$B = B_m sin(kx-\omega t)$ magnetic field

$c = \frac{E}{B} = \frac{1}{\sqrt{\mu_0\varepsilon_0}} \approx 3.0\times10^8 m/s$ wave speed vacuum

Energy Transport

$\vec{S} = \frac{1}{\mu_0}\vec{E}\times\vec{B}$ Poyting vector

$I = \frac{1}{c\mu_0}E_{rms}^2$ intesidade da onda

$I = \frac{power}{area} = \frac{P_s}{4\pi r^2}$ onda todos os lado intensidade

Radiation Pressure

$p_r = \frac{i}{c}$ total absorption

$p_r = \frac{2i}{c}$ total reflection

vezes A area para dar a forca feita pela onda

Polarizacao

$i = \frac{1}{2}i_0$ passar por filtro polarizador

$i = i_0 cos^2\theta$ bater no filtro a um angulo

Interferencia Difracao

Interferencia

$\delta = r_2 - r_1 = dsin\theta$ diferenca caminho ondas, d separacao fendas, θ angulo normal do ecra/linha q parte na normal ate ao ponto

$\delta = dsin\theta_{brilhante} = m\lambda$ m multiplo do comprimento de onda

$\delta = dsin\theta_{escura} = \left(m+\frac{1}{2}\right)\lambda$ m multiple de meio

$y = Ltan\theta \approx Lsin\theta$ L distancia ecra de visualizacao, L»d d»λ

$y_{brilhante} = \frac{\lambda L}{d}m$ distVert brilhantes

$y_{escura} = \frac{\lambda L}{d}\left(m+\frac{1}{2}\right)$ distVert escura

Difracao

$asin\theta = m\lambda$ minimos, a largura

$\theta_{min} = \frac{\lambda}{a}$

Difracao Circular

$\theta = 1,22\frac{\lambda}{d}$ d diametro