1 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 $\omega' \approx \omega$
$E(t) \approx \frac{1}{2}kx_m^2 e^{-\frac{bt}{m}}$

2 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...

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

$\varepsilon_0 \Phi = q_{enc}$

ChargedIsolConducExternEF

σ : charge per unit area
$E = \frac{\sigma}{\varepsilon_0}$

Cylindrical Line

λ : linear charge density
$E = \frac{\lambda}{2\pi\varepsilon_0 r}$

Planar Non-conducting Sheet

$E = \frac{\sigma}{2\varepsilon_0}$

Planar Two Conducting Plates

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

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

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

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 GroupOfPoint-Charges

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
$R = \rho \frac{L}{A}$
$p - p_0 = p_0 \alpha (T - T_0)$

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