## Oscilations

### Simple Harmonic Motion

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

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

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

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

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

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

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

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

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

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

$\lambda$: 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

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

$\vec{F}=k\frac{q_1q_2}{r^2}\hat{r}$

$k=\frac{1}{4\pi\epsilon_0}=8.99\times10^9\,N\cdot m^2/C^2$

$\epsilon_0=8.85\times10^{-12}\,C^2/N\cdot m^2$

### Charge is Quantized

$q=ne$, $n=\pm1,\pm2,\pm3\ldots$

$e=1.602\times10^{-19}C$

## 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 $z>>d$

$E=\frac{1}{2\pi\epsilon_0}\frac{p}{z^3}$

### 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

$\sigma$: charge per unit area

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

### Cylindrical Line

$\lambda$: 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

$1N/C=\left(1\frac{N}{C}\right)\left(\frac{1V\cdot C}{1J}\right)\left(\frac{1J}{1N\cdot m}\right)=1V/m$

$1eV=e(1V)=\left(1.60\times10^{-19}C\right)(1J/C)=1.60\times10^{-19}J$

### 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 System-PointCharges

$U=W=q_2V=\frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r}$

## Capacitance

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

### Calculating Capacitance

$C=\frac{\varepsilon_0A}{d}$ : 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

$C=4\pi\varepsilon_0R$ : esfera isolada

### Capacitors

$C_{eq}=\sum_{j=1}^n(C_j)$ : 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

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

$u=\frac{1}{2}\varepsilon_0E^2$ : energy density

### Capacitor with a Dieletric

If dieletric replace $\varepsilon$ 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 ($1\Omega$) = 1 volt per ampere = 1 V/A

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

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

$p-p_0=p_0\alpha(T-T_0)$

### Power Potencia

$P=iV$ : rate eletrical energy transfer

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

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