① Waves

ⓐ String – its normal modes

ⓑ 1-d wave equation + solutions

$$k_n = n\frac{\pi}{L} \qquad \omega_n = v k_n = \sqrt{\frac{T}{\mu}}\,\frac{\pi}{L}$$

↑ string

$n = 1$ fundamental
> 1 overtones

$$\begin{Bmatrix} \cos(k_n x) \\ \sin(k_n x) \end{Bmatrix} \times \begin{Bmatrix} \sin(\omega_n t) \\ \cos(\omega_n t) \end{Bmatrix}$$

choose based on boundary conditions

ⓒ Longitudinal: $v = \sqrt{\frac{Y}{\rho}}$

Open + Closed boundaries

Gases: $v = \sqrt{\frac{\gamma p}{\rho}} = \sqrt{\frac{\gamma R T}{A_W}}$

ⓓ 2-d

ⓔ Fourier Series

Arbitrary $y(x,0)$

$$y(x,0) = \sum_{n=1}^{\infty} B_n \binom{\sin}{\cos}\left(\frac{n\pi}{L}x\right)$$

$$y(x,t) = \sum_{n=1}^{\infty} B_n \binom{\sin}{\cos}\left(\frac{n\pi}{L}x\right) \times \cos(\omega_n t)$$

if $y(x,0) = 0$
$\frac{\partial y}{\partial t}(x,0)$ given
becomes sin

→ how to solve for B_n

→ parity

(f) Beats

(g) Traveling Waves

(h) Doppler Effect

(i) Energy in waves

2) Electrostatics

a) Force $\vec{F}_1 = \frac{q_1 q_2}{r_{12}^2}\hat{r}_{12} = \frac{q_1 q_2}{4\pi\varepsilon_0 r_{12}^2}\hat{r}_{12}$

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b) Energy $U = \frac{q_1 q_2}{r_{12}} = \frac{q_1 q_2}{4\pi\varepsilon_0 r_{12}}$

($\rightarrow \infty$ as $r_{12} \rightarrow \infty$)

c) Electric Field

$$\vec{F} = q\vec{E}$$

d) Field Lines: start on + charge
end on − charge

e) Q densities → λ, σ, ρ

linear area volume

$\vec{E}$ from continuous charge distributions

f) Φ_E → electric flux

(g) Gauss's Law

$\vec{E}$, φ from symmetric charge distributions

"contained charge"

line, sheet charges

(h) Forces on Sheets of charge

(i) Electric field energy

$$\int \frac{E^2}{8\pi} d(\text{volume})$$

(j) $\vec{\nabla} f$, $\vec{E} = -\vec{\nabla}\phi$

ϕ = electric potential

(k) Computation of potential for continuous charges; point, spherical symmetry, line charge, sheet, volume density.

(l) relation between field lines + equipotentials

(m) $\vec{\nabla} \cdot \vec{E} = 4\pi\rho$

$-\nabla^2 \phi = 4\pi\rho$

$-\nabla^2 \phi = 0$ (no charge)

→ average of ϕ around a sphere is value at center.

→ no stable equilibrium of charge in free space

(n) Conductors : $\vec{E} = 0$ inside.

- Equipotentials
- Shielding : $\vec{E} = 0$ inside a cavity.

(i) Image Charges

(j) Capacitance – parallel, series

(k) Energy, Forces