

Chapter 1 in text book

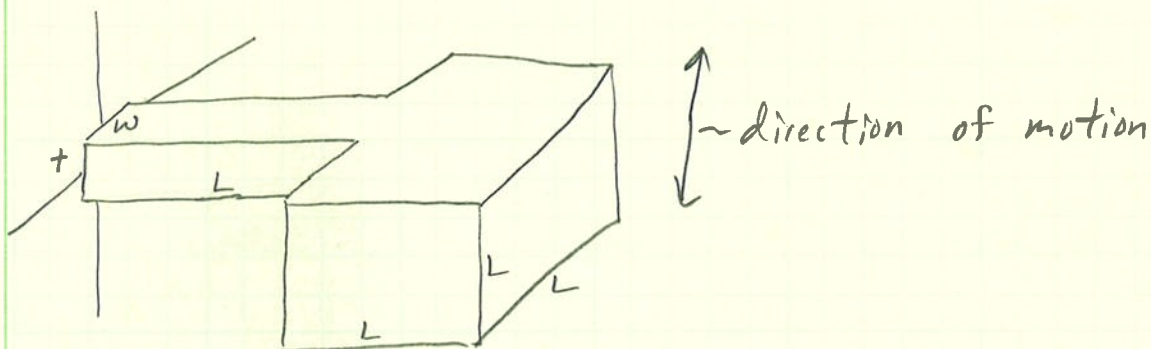
1) Miniaturization and Scaling

The relative importance of physical quantities and forces varies with size.

→ Consider : Macro world : $1m \leq L \leq 2mm$

Micro world : $500\mu m \leq L \leq 0.5\mu m$

Example : Cantilevered Beam with attached Proof Mass



Beam \rightarrow spring constant $= k = \frac{Ewt^3}{L^3}$

$E \equiv$ Young's Modulus

let $w = \alpha L$ and $t = \beta L$

$$\therefore k = \frac{E\alpha\beta^3 L^4}{L^3} = E\alpha\beta^3 L$$

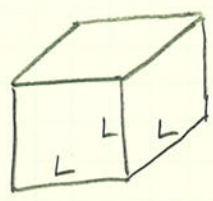
$\therefore L \downarrow : k \downarrow \rightarrow$ spring gets softer and size shrinks

Proof Mass $\rightarrow m = \delta V = \delta L^3 \rightarrow$ mass gets much smaller as size shrinks

$$\text{Natural Frequency} = \omega = \sqrt{\frac{k}{m}} = \sqrt{\frac{E\alpha\beta^3 L}{\delta L^3}} = \frac{1}{L} \sqrt{\frac{E\alpha\beta^3}{\delta}}$$

\rightarrow resonant frequency increases as size shrinks

Example : Cubic Mass



$S = \text{Surface Area} = 6L^2$

$V = \text{Volume} = L^3$

Consider the ratio : $\frac{S}{V} = \frac{6L^2}{L^3} = \frac{6}{L}$

→ S:L increases as size shrinks

→ at the micro scale physical quantities and forces that pertain to surface area are more important than ones that pertain to volume

Surface Area Effects

- friction
- surface tension (fluidics)
- Van der Waals forces
- Casimir forces
- electrostatic force



more important in the micro + nano world

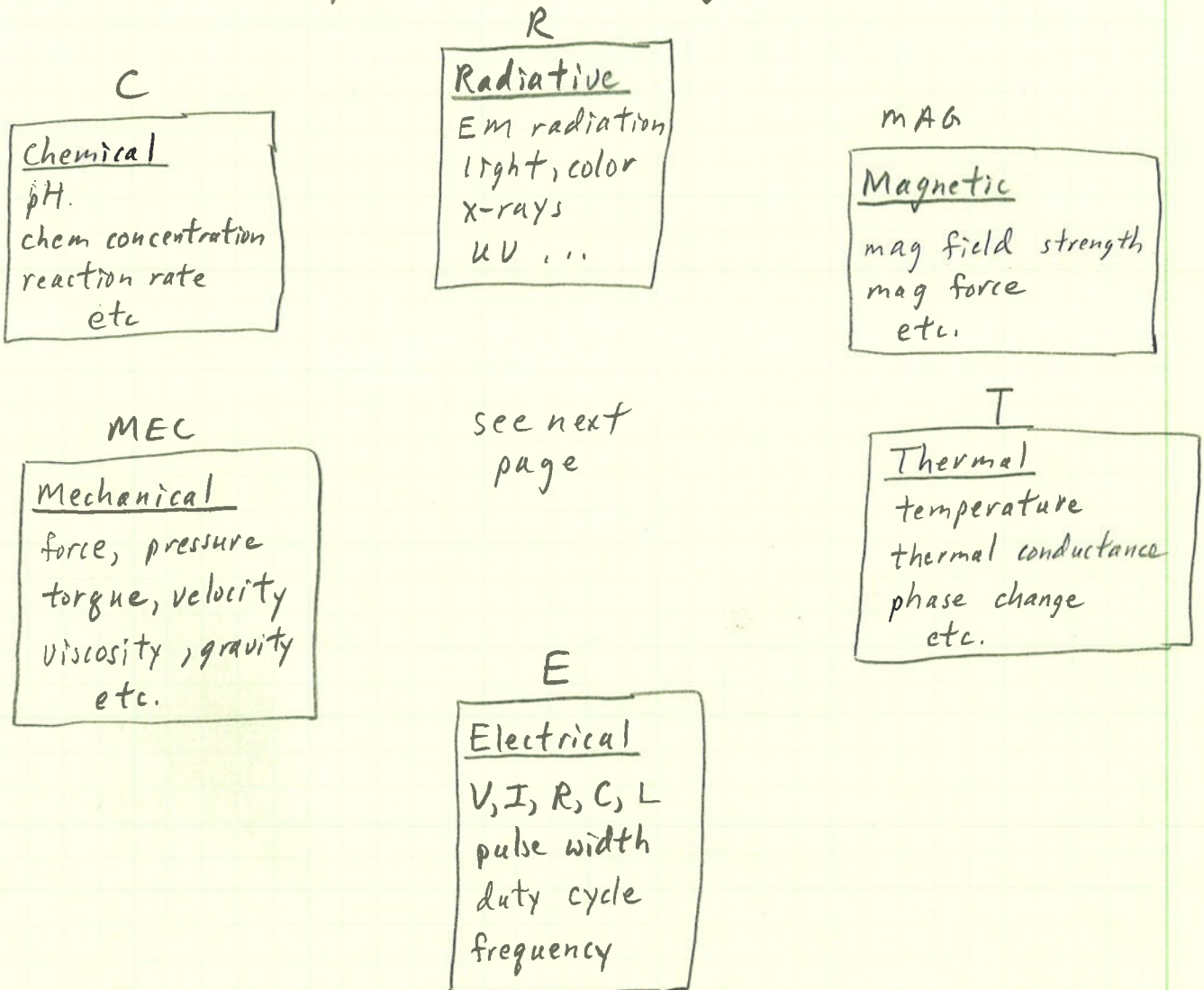
Volume Effects

- gravitational force
- inertial force
- thermal time constant
- magnetic force



more important in the macro world

1) Phenomena are categorized into "Energy Domains"
 → 6 defined energy domains involving MEMS



Transducer: a device that converts an "item" from one energy domain to another

→ sensors + actuators

Sensor → input transducer: converts C, R, T, MAG, MEC to E } loose definition
Actuator → output transducer: converts E to C, R, T, MEC, MAG }

From Text page 16

