

OneNote for Windows 10

Vikas Sharma

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SMI-L-11

Tuesday, February 22, 2022 2:23 PM

Magnetostriction

[Ferromagnetic material]

undergo some change in its shape

magnetic field intensity (H)

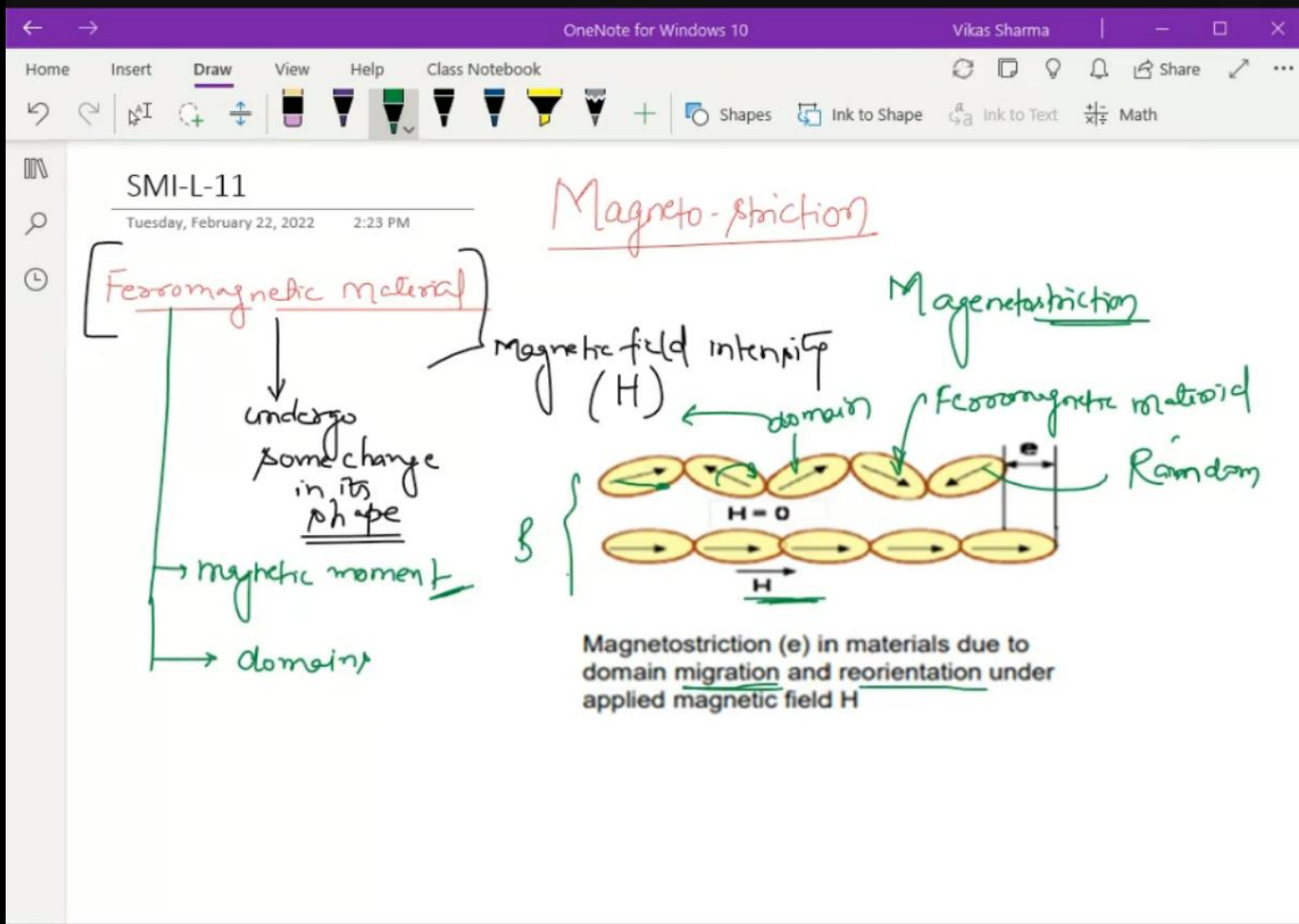
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05:32 1:08:54

100%

ENG IN 10:33 AM 3/3/2022 13

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[illegible]

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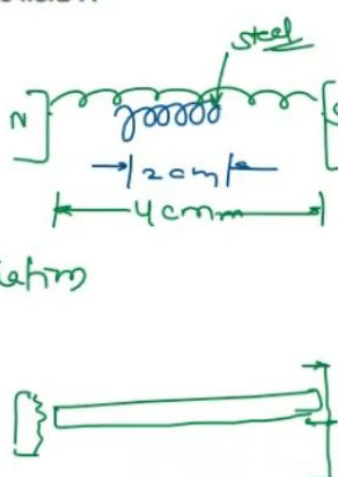
domains

tensile form
→ compressed form ←

Magnetostriction (e) in materials due to domain migration and reorientation under applied magnetic field H


steel
N S
→ 2 cm
4 cm

Joule law → Direct law
↓
James Prescott Joule ↳ actuation



D

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tenstile form
→ compressed form ←

Joule law → Direct law
↓
James Prescott Joule
Sensor based application
Villari 1900

Ni, Co, Fe
Cobalt
Iron

May → [FMM] → strain Deformation
[H] change in ΔH
← load, deform

actuation
Reciprocal effect

ΔL

Direct law
Converse law
Reciprocal effect

Sensor applications

D

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Iron → change in ΔH

Magnetic Energy

Sensor applications

Transformed

Mechanical energy

Reciprocal effect

ΔL elastic

Material	Magnetostriction ($\times 10^{-6}$)	Curie Temp (K)
Fe →	20	633
Ni	-40	1043
Co	-60	350
NiCo	186	600
TbFe ₂	1750	703
Terfenol-D (Tb _{0.3} Dy _{0.7} Fe _{1.9})	2000	380
Galfenol	300	600

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Magnetic Energy $\xrightleftharpoons{\text{Transformed}}$ Mechanical energy \downarrow elastic

Material	Magnetostriction ($\times 10^{-6}$)	Curie Temp (K)
Fe \rightarrow	20	633
Ni	-40	1043
Co	-60	350
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TbFe ₂	1750	703
\rightarrow Terfenol-D (Tb _{0.3} Dy _{0.7} Fe _{1.9})	2000	380
Galfenol	300	600

elongation (+)
compression (-)

NOT Naval Ordnance Laboratory (USA)

Rare-earth materials \rightarrow magnetostriction (cryogenic temp.)

Terbium (Tb)
Dysprosium (Dy) } Iron

Tb_xDy_{1-x}Fe_y

D

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Rare-earth materials → magnetorstriction (cryogenic temp.)

Terbium (Tb) } Iron
Dysprosium (Dy) }

$x = 0.27 \text{ to } 0.3$
 $y = 1.9 \text{ to } 2.0$

SONAR

Naval Ordnance Laboratory (USA)

composition of alloy

$Tb_x Dy_{1-x} Fe_y$

Brittle
Low tensile strength



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37:29

1:08:54

25°C
HazeENG
IN10:52 AM
3/3/2022

13

[illegible]

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FeGa } → Galenol → 1998

- high tensile strength
- Ductile
- limited variation -20°C to 80°C

$Tb_x Dy_{1-x} Fe_y$ } x, y } vary

- magnetic
- Elastic

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47:40 1:08:54

25°C Haze

10:57 AM 3/3/2022

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→ limited variation -20°C to 80°C

const
Elasticity

$\sigma = E \epsilon$

effect of magnetic field

$\left\{ \begin{matrix} B_x & D_{y \rightarrow x} & E_{cy} \end{matrix} \right\}$

Non-linear nature

$\left\{ \begin{matrix} x & y \end{matrix} \right\}$

6.27

→ Magnetic
→ Elastic

$\rightarrow E$

D

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→ limited variation -20°C to 80°C

const
Elasticity
↓
 $\sigma = E \epsilon$

$\begin{matrix} T_{bx} & D_{y \rightarrow x} & E_{cy} \end{matrix}$

↓
Non-linear nature

$\begin{matrix} x, y \\ \updownarrow \\ 0.27 \end{matrix}$ } vary
→ Magnetic
→ Elastic

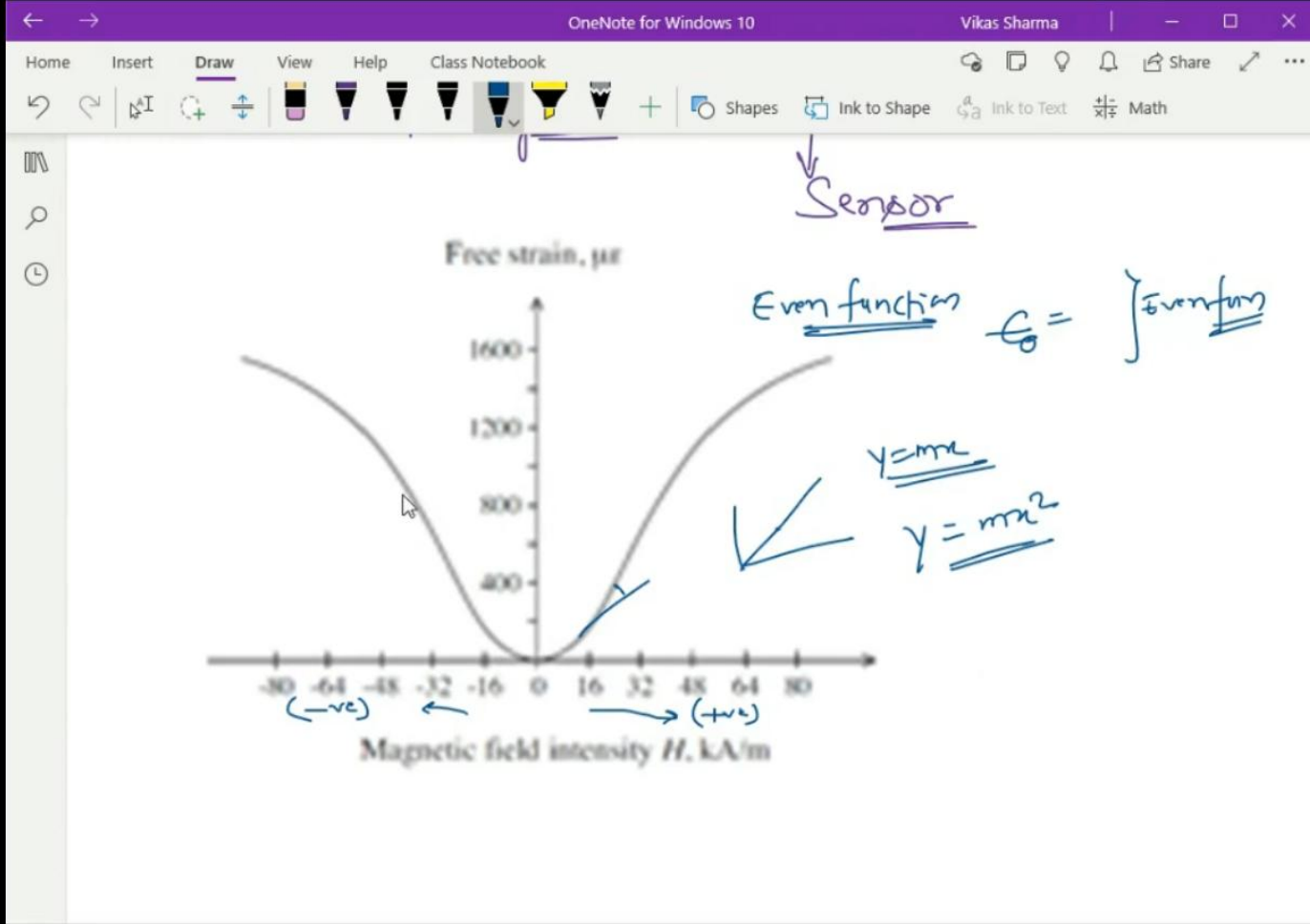
Effect of magnetic field
Temperature

E → magnetic permeability
→ Magneto-mechanical coupling
→ Mechanical damping
→ piezomagnetic coefficients

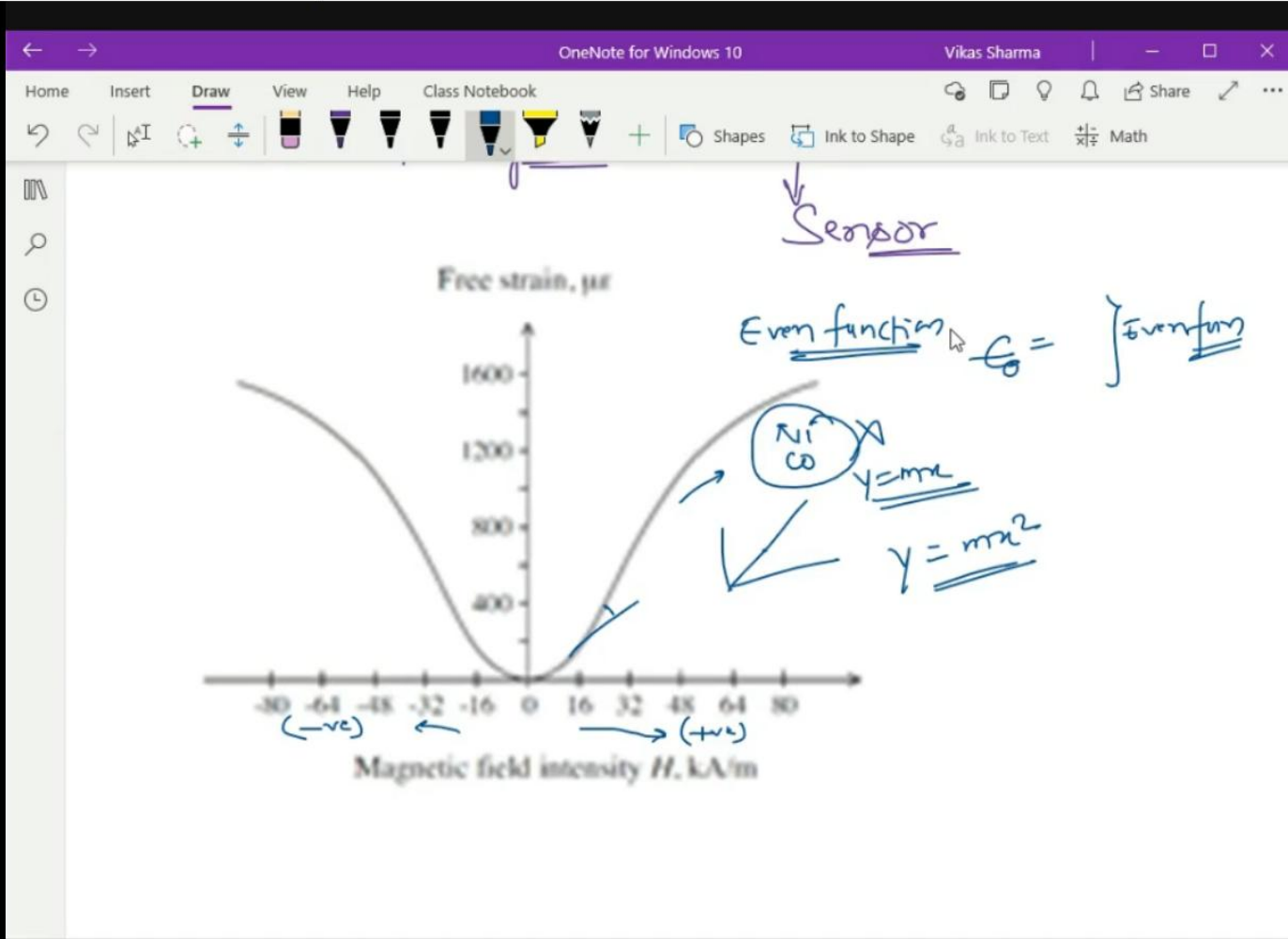
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Tuesday, February 22, 2022 2:23 PM

Ferromagnetic material

undergo some change in its shape

→ magnetic moment

→ domains

tensile form

→ compressed form

Magnetostriction

$B = \mu H$

magnetic field intensity (H) → main

Ferromagnetic material

Random

increase in length

(-)

Magnetostriction (e) in materials due to domain migration and reorientation under applied magnetic field H

steel

N S

→ 2 cm

← 4 cm



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