

ETME 3120

Maintenance of Mechatronics Systems

Lesson 6: Non-Destructive Testing and Evaluation

Refer to Chapter 5 in the textbook

Reference: Productivity and Reliability-Based Maintenance Management, M. Stephens, 2010

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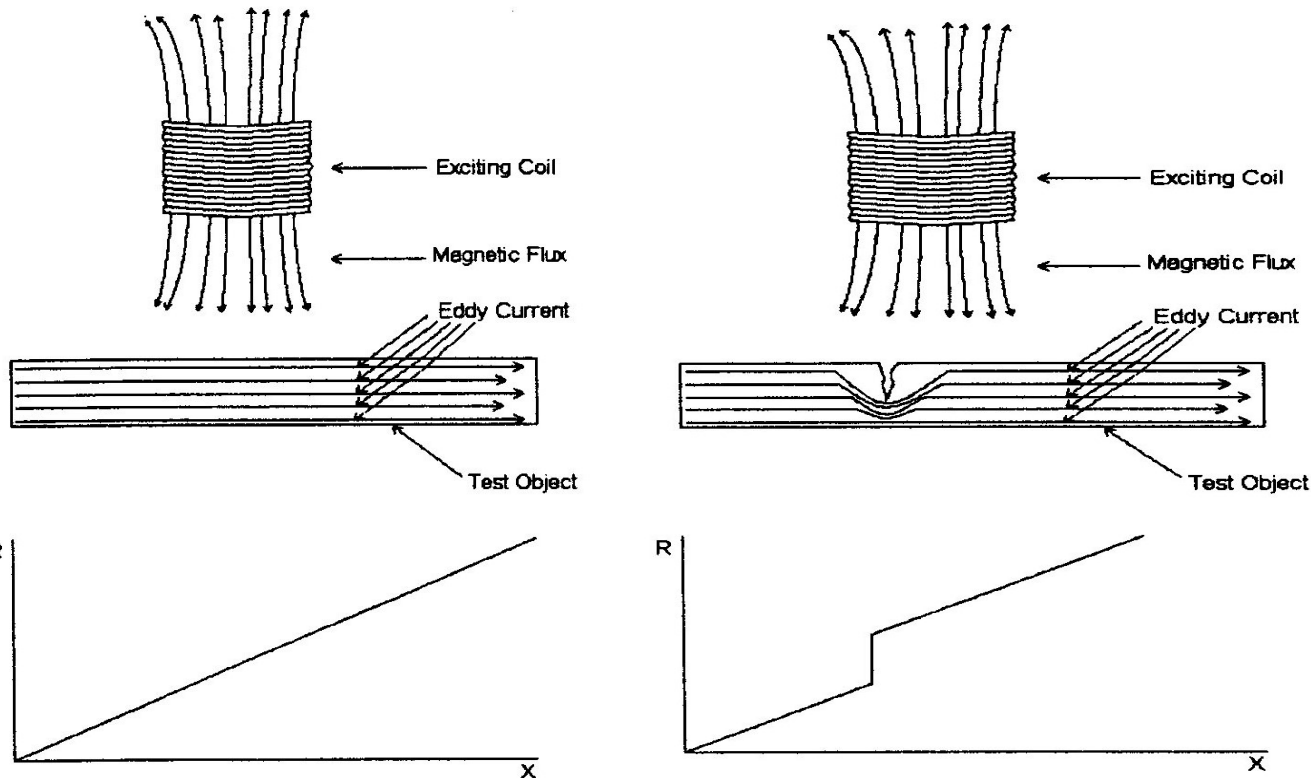
Eddy Current (Slide 1)

- Eddy currents are induced directional flow of electrons in the test object under the influence of an electromagnetic field.
- Any measured impedance in the flow points to the presence of flaws or other non-conformities.
- Originally part geometry interfered but highly sophisticated excitation sources and probes have broadened this application.
- Evaluation of the flaw includes flaw size, orientation, characteristics, and origin.
- Fun with Physics: Eddy currents

<https://www.youtube.com/watch?v=ezXVzc64qRE>

Eddy Current (Slide 2)

- This technique provides for a fast and effective testing of critical parts operating in a hazardous and harsh environment without contact with the test object.
- Applications: in-service inspection of tubes in steam generators and heat exchangers in conventional and nuclear power plants.



Radiology (Slide 1)

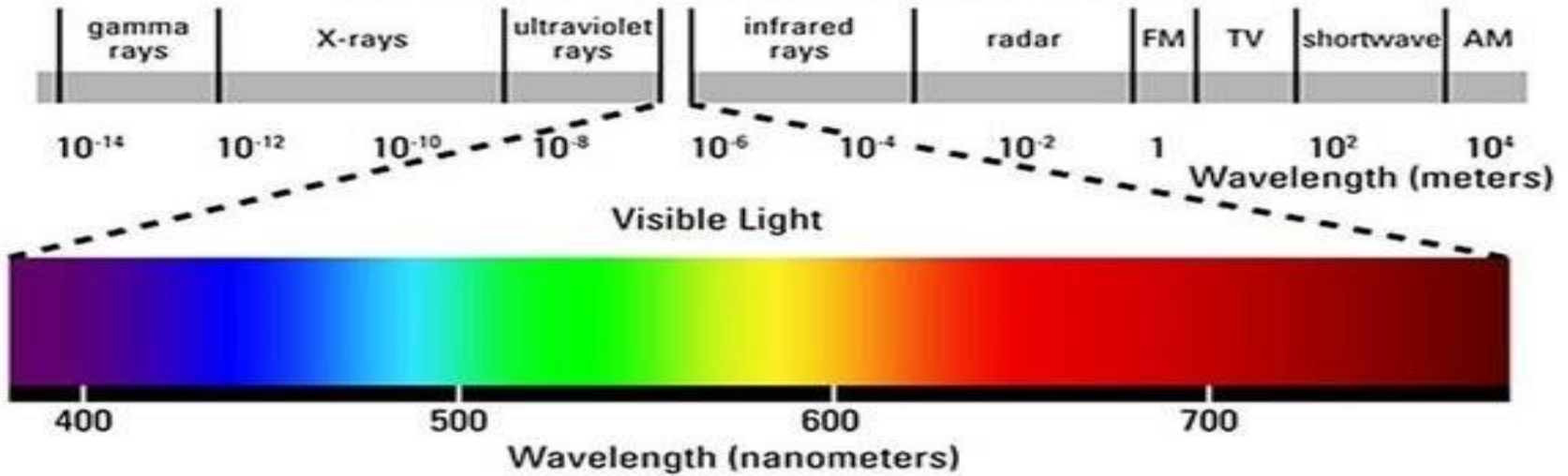
- This technique uses penetrating radiation to obtain an internal latent image of an object.
- The most common types of radiation are x-rays and γ -rays.
- Very short wavelengths enable them to penetrate substances that reflect/absorb visible light.
- Just like visible light, X-rays and γ -rays can expose a film and produce a latent image.
- X-rays and γ -rays can penetrate through Visible light can penetrate through objects and take latent images through them, just like visible light can penetrate through glass to take images through it.
- X-rays and γ -rays are **electromagnetic** waves like visible light, they have very short wavelengths and travel at the speed of light.

Wavelengths

- $Wavelength (\lambda) = \frac{wave\ propagation\ speed}{Frequency}$
- All electromagnetic waves propagate at the speed of light, which is $300,000\ km/s = 3 \times 10^8\ m/s$
- Note that *acoustic waves travel at 343 m/s in air at 25°C*
- **Question 1:** A cellular carrier uses the frequency 1.9 GHz for cellular communications. What is the wavelength of the electromagnetic signals at this frequency?
- Solution: $\lambda = \frac{3 \times 10^8}{1.9 \times 10^9} = 0.158\ m = 15.8\ cm$
- **Question 2:** The red light lasers at a wavelength of 700 nm are commonly used in spectroscopic applications, What is the frequency of the red color light at that wavelength?
- Solution: $700 \times 10^{-9} = \frac{3 \times 10^8}{Frequency}$ thus, $freq = 4.28 \times 10^{14}\ Hz$

Radiology (Slide 2)

The Electromagnetic Spectrum



Gamma-ray

X-ray

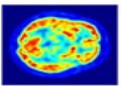
Ultraviolet

Visible

Infrared

Microwave

Radio



Terrestrial gamma-ray flashes

PET scan

Airport security scanner

UV light from the Sun



Night vision goggles

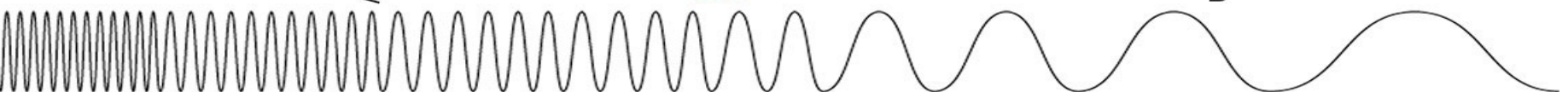
TV Remote Control

Microwave oven

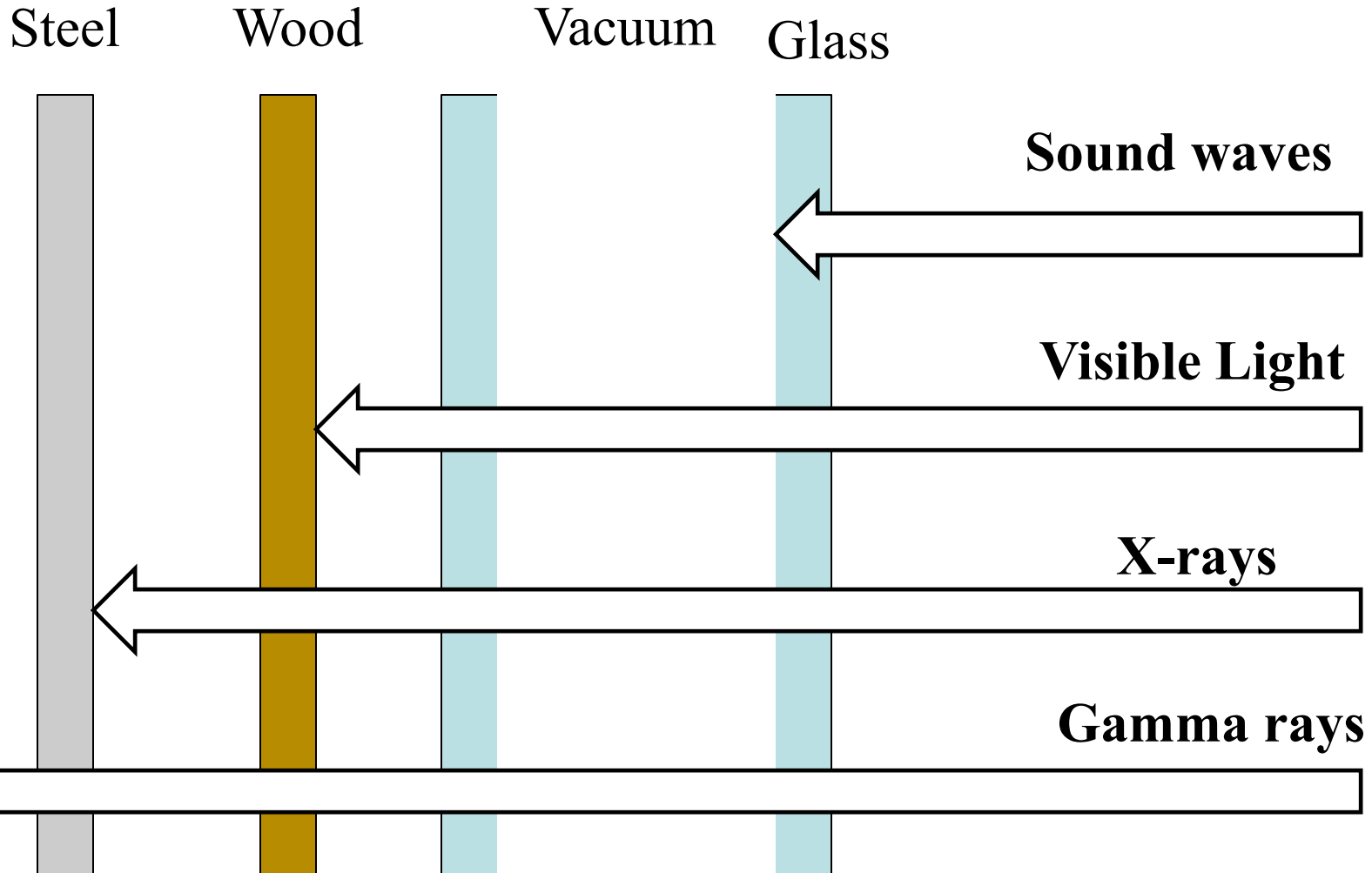
Aircraft communication

Amateur radio

AM radio

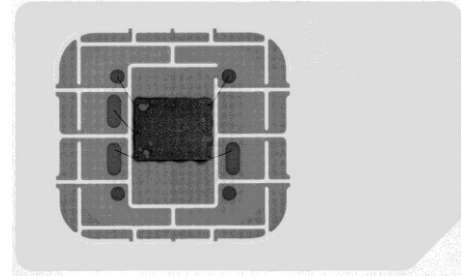


Example



Radiology (Slide 3)

- x-rays are emitted when an electron beam strikes a solid object, usually a tungsten target in vacuum tube..
- Natural sources of γ -rays are disintegrating radioactive substances such as radium.
- This approach can point to lack of homogeneity of the chemical composition, non-uniform density, internal cracks, voids, and discontinuities.
- Radiography can be used for the evaluation of forgings, welds, castings, and non-metallic fabricated parts.



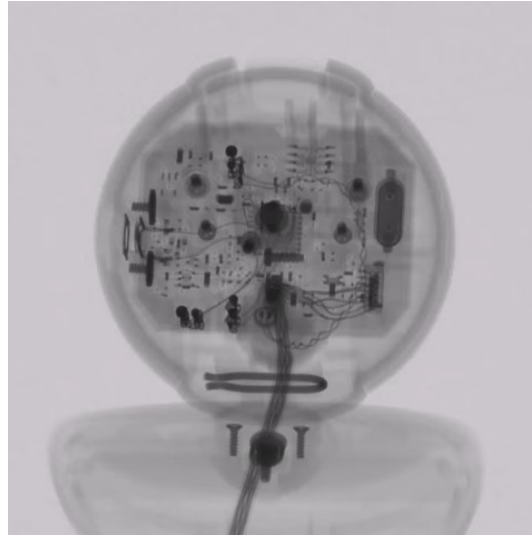
X-ray image of a SIM card.

Source: Wikimedia Commons



Tomography

- Industrial Computed Tomography (CT) Provides information in three-dimensions.
- CT scans provide a 3D image from a combination of X-ray scans at different angles.
- This method has been used to analyze assembly parts and detect cracks and defects.



CT Scan unit in a hospital (Left). CT scan of a webcam (Right)

Source: Wikimedia Commons https://en.wikipedia.org/wiki/CT_scan#/media/File:UPMCEast_CTscan.jpg

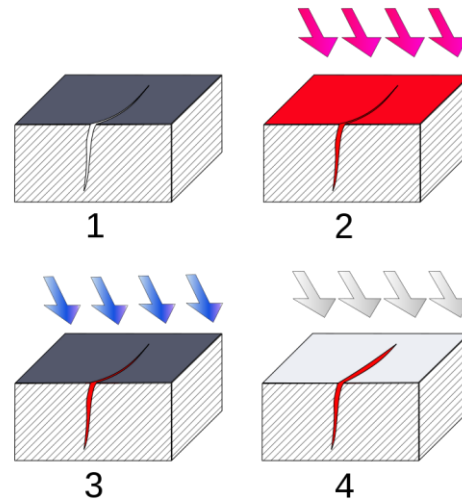
Wikimedia Commons: https://en.wikipedia.org/wiki/File:Webcam_CT_transmissions.ogv

Magnetic Resonance Imaging

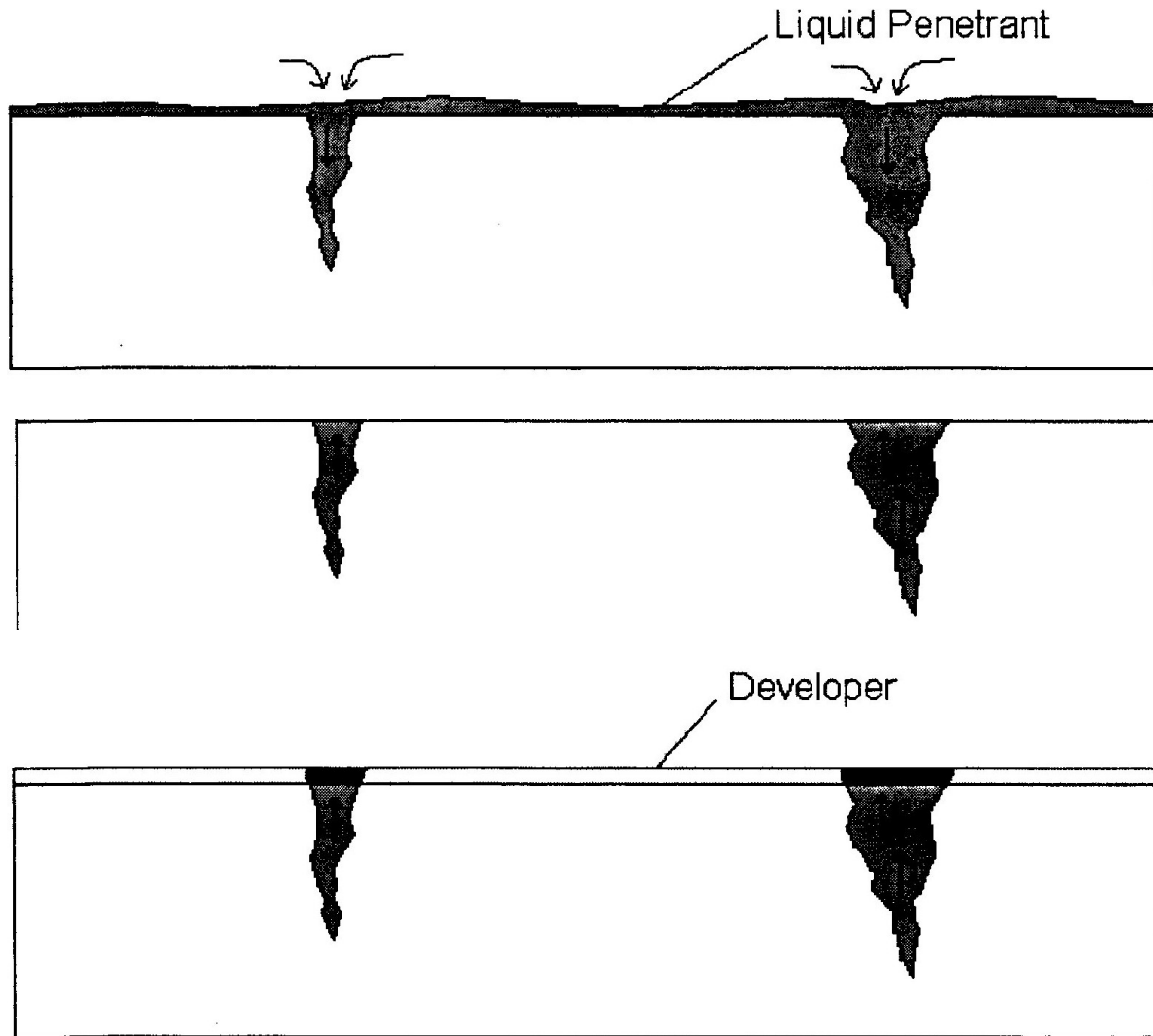
- MRI is in fact a tomography imaging procedure that allows the production of multi-dimensional images.
- MRI is capable of generating multi-dimensional images in any orientation without the ionization requirements or the need for the use of radioactive materials.

Liquid Penetrant

- Method for detecting surface cracks for metallic as well as nonmetallic objects.
- The technique can be used to detect extremely small open surface defects.
- In this method a liquid penetrant with a dye is sprayed on the surface and left to dwell then cleaned off. A developer film is then applied, and draws the liquid from the cracks to the surface under the capillary effect.

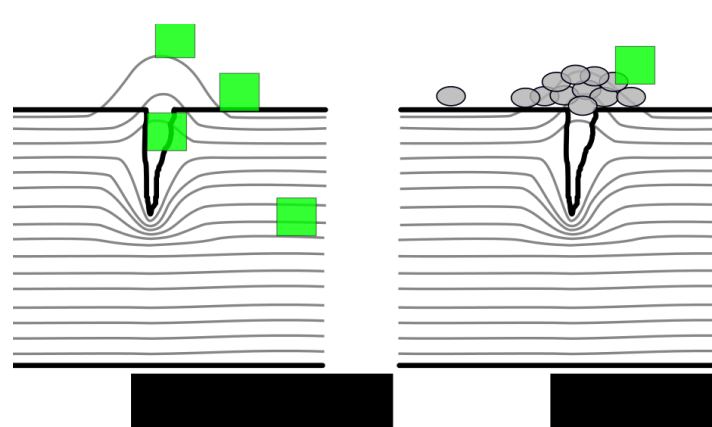


Liquid Penetrant Testing



Magnetic Particle Testing

- It is a testing method for detection of surface or subsurface discontinuities and defects in ferrous materials.
- Force lines are formed around a magnetized steel bar. These lines can be plotted by sprinkling fine iron fillings on a clean magnetized steel bar.
- A crack, inclusion, or any discontinuity on the object will disturb these force lines.



Magnetic Particle Testing

