ECE343 Spring 2025

Objective 2: Practical Applications

UNITED STATES
AIR FORCE
ACADEMY

Nominal Schedule

Lesson	Topics	Reading	Notes
1	Course Overview & Introduction	Ch.1	LO 1.1-1.2
Chapter 2: Electric and Magnetic Fields			
2	Fields, Parameters, Field Quantities	Ch. 2	LO 2.1-2.2
Chapter 3: Transmission Lines			
3	Lumped Element Model	3.1-3.4	LO 3.1
4	Telegrapher's Equations	3.5-3.6	LO 3.1
5	Characteristic Impedance & Wave Propagation	3.7-3.9	LO 3.2
6	Coaxial, Reflection Coefficient, VSWR	3.10,3.12-3.14	LO 3.2-3.3
7	Terminated Transmission Lines	3.15,3.17-3.19	LO 3.4
8	Impedance Matching	3.21-3.23	LO 3.4
9	Impedance Matching	3.21-3.23	LO 3.4
10	Smith Charts	Supplemental	LO 3.5
11	Smith Charts	Supplemental	LO 3.5
12	Smith Charts	Supplemental	LO 3.5
13	Smith Charts	Supplemental	LO 3.5
14	Transients	Supplemental	LO 3.6
15	Reflection/Transmission Coefficient Lab	Lab Packet	LO 3.7
Chapter 4: Vector Analysis			
16	Vector & Coordinate System Review	Ch. 4	LO 4.1-4.4 **GR 1 due**
Chapter 5: Electrostatics			
17	Coulomb's Law	5.1-5.3	LO 5.1
18	Surface and Volume Charge	5.4	LO 5.1
19	Gauss' Law (Integral Form)	5.5-5.6	LO 5.2
20	Gauss' Law (Differential Form)	5.7-5.8	LO 5.2
21	Electric Potential	5.9-5.10, 5.15	LO 5.3

Ch 1 Learning Objectives

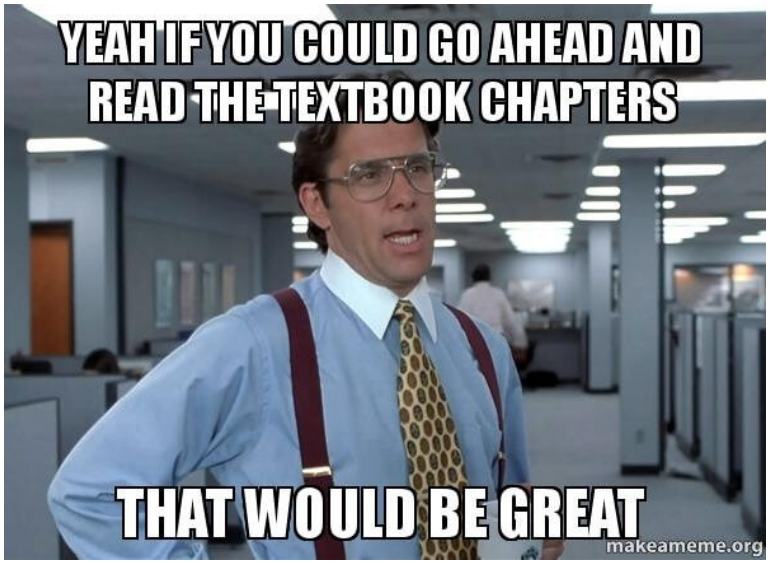
1.1 I can articulate what I will learn and how I will be assessed in this course.

1.2 I can articulate practical applications of electromagnetics.

The Story of Energy & Waves

Read. The. Book:

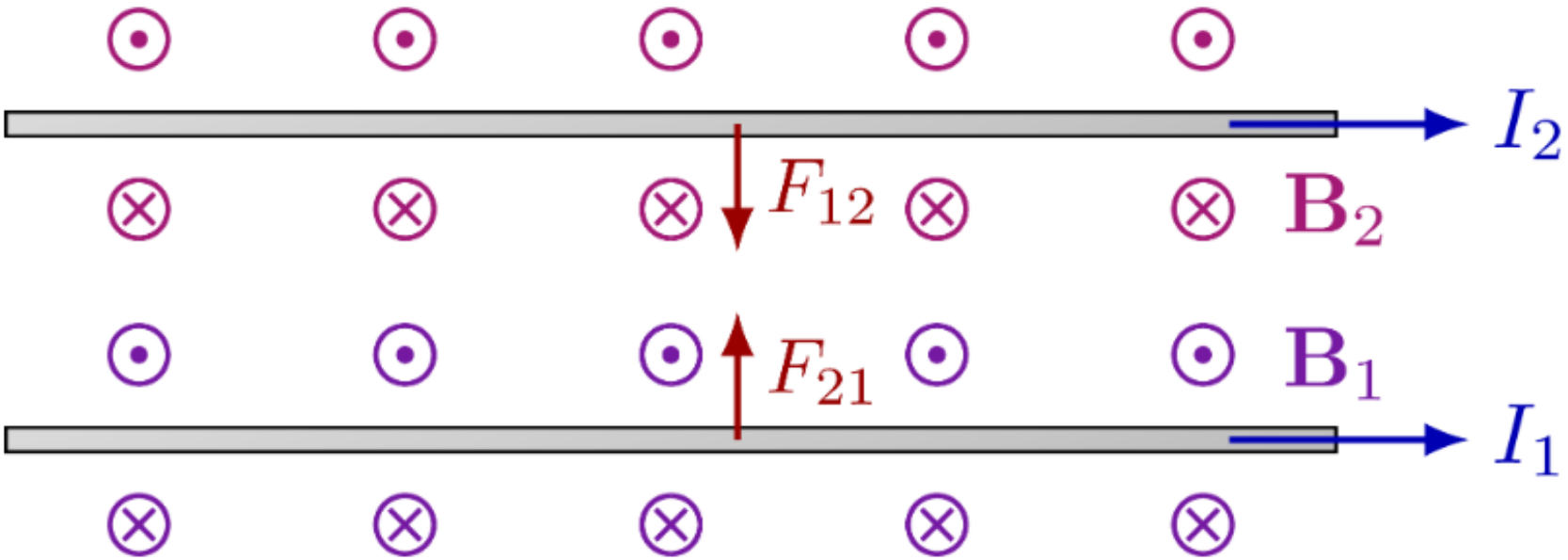
- Chapter 2 - Fields
- Chapter 3 - Transmission Lines
- Chapter 4 - Vector Analysis
- Chapter 5 - Electrostatics
- Chapter 6 - Current & Conductivity
- Chapter 7 - Magnetostatics
- Chapter 8 - Dynamic Fields
- Chapter 9 - Plane Waves



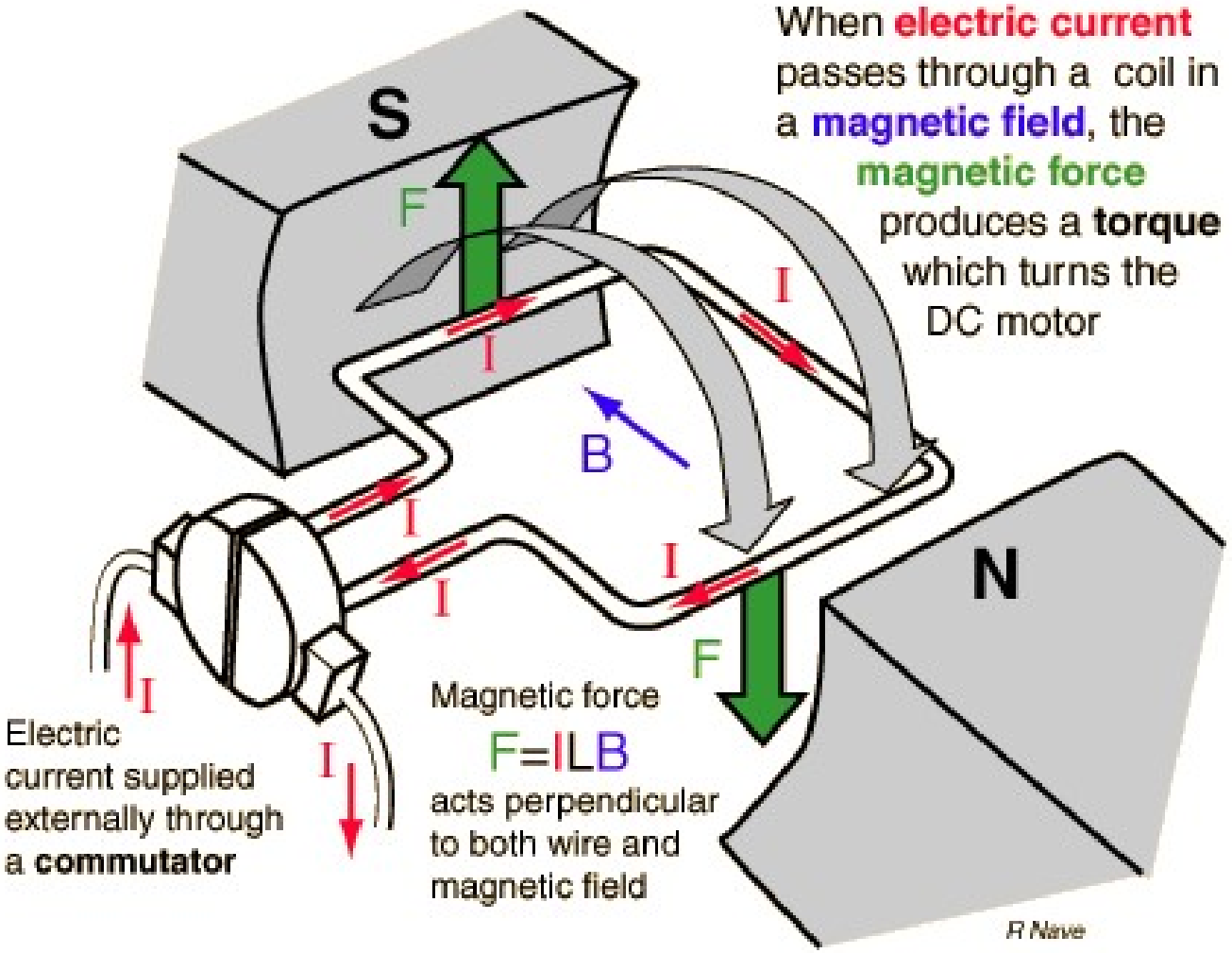
Maxwell's Equations

	Integral Form	Differential Form
Gauss	$\oint \vec{E} \cdot d\vec{S} = Q_{\text{enc}}$	$\nabla \cdot \vec{E} = \frac{\rho_v}{\epsilon}$
Gauss	$\oint \vec{H} \cdot d\vec{S} = 0$	$\nabla \cdot \vec{H} = 0$
Faraday	$\oint_C \vec{E} \cdot d\ell = -\mu \int \frac{\partial \vec{H}}{\partial t} \cdot d\vec{S}$	$\nabla \times \vec{E} = -\mu \frac{\partial \vec{H}}{\partial t}$
Ampere	$\oint_C \vec{H} \cdot d\ell = \int \vec{J} \cdot d\vec{S} + \epsilon \frac{\partial}{\partial t} \int \vec{E} \cdot d\vec{S}$	$\nabla \times \vec{H} = \vec{J}_C + \epsilon \frac{\partial \vec{E}}{\partial t}$

Ampere's Force Law - Parallel Wires



Ampere's Force Law



Faraday's Law & KVL

Closed Contour (line) Integral

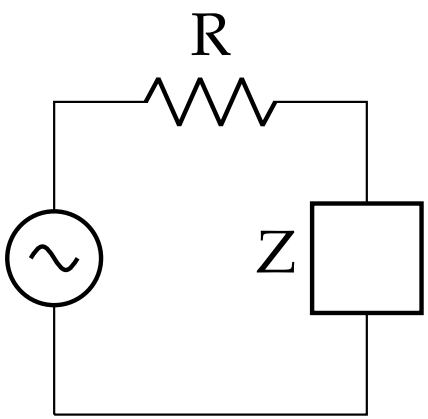
Vector dot product

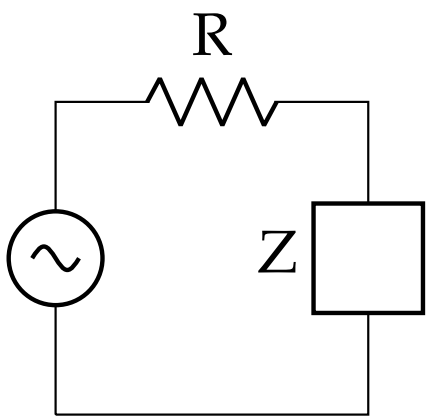
Time rate of change of magnetic field

$$\oint_C \vec{E} \cdot d\vec{\ell} = -\mu \int \frac{\partial \vec{H}}{\partial t} \cdot d\vec{S}$$

Incremental length on contour

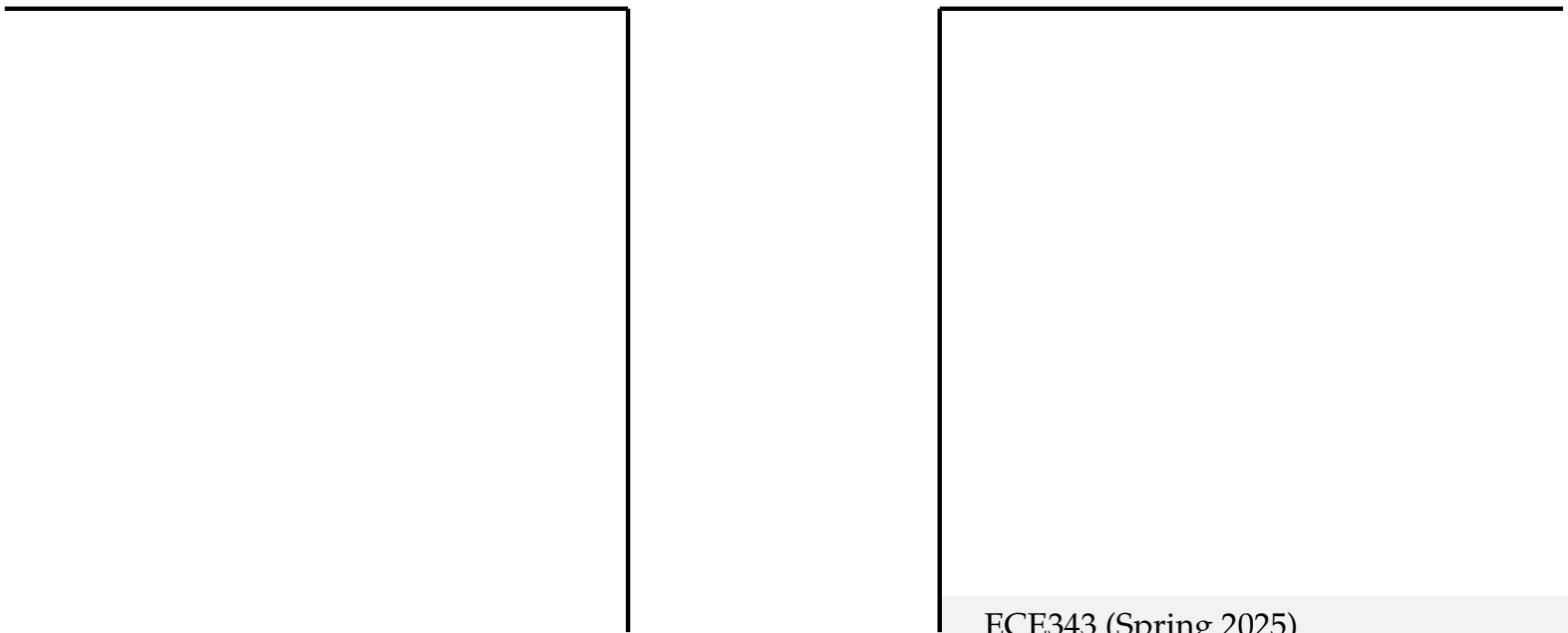
Area bounded by contour



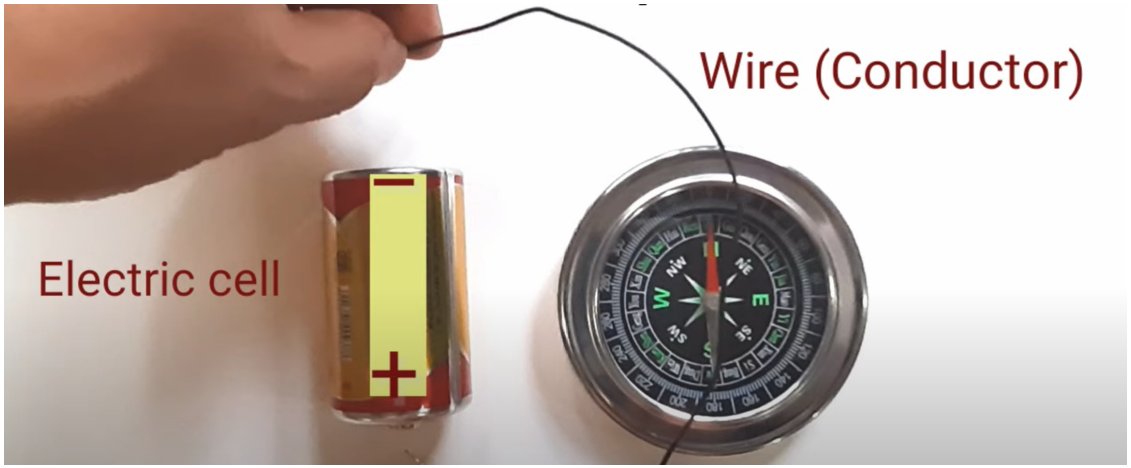


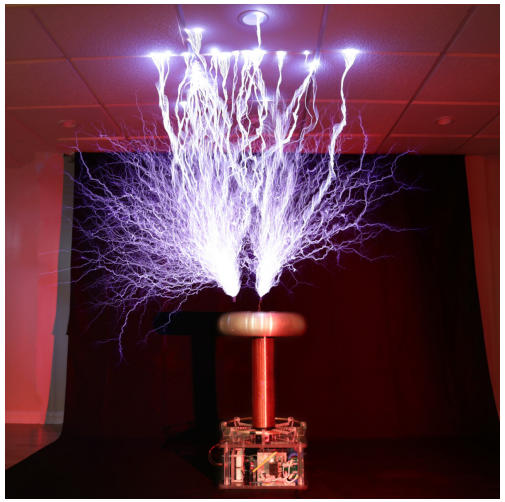
Current Continuity & KCL

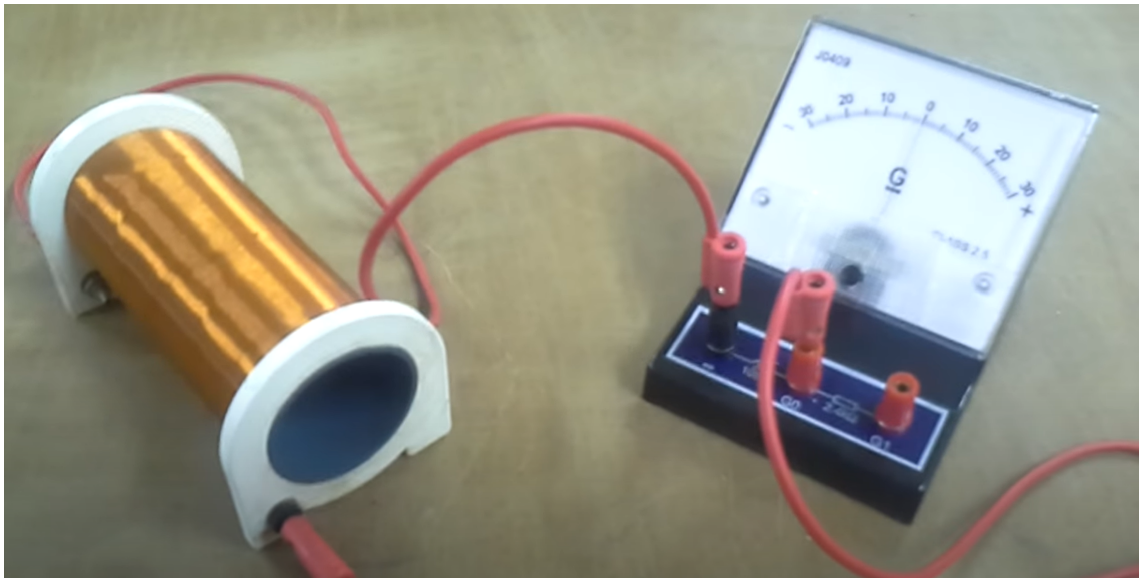
$$\nabla \cdot \vec{J} = -\frac{\partial \rho_V}{\partial t}$$



Emag Demos


Wire (Conductor)
Electric cell





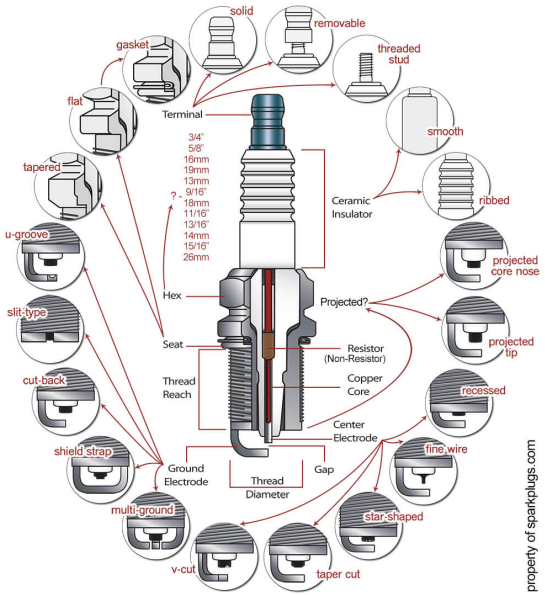

solid
removable
threaded stud
gasket
flat
Terminal
smooth
tapered
ribbed
u-groove
projected core nose
slit-type
projected tip
cut-back
recessed
shield strap
fine wire
multi-ground
star-shaped
v-cut
taper cut
Ceramic Insulator
Hex
Projected?
Seat
Resistor (Non-Resistor)
Copper Core
Thread Reach
Center Electrode
Ground Electrode
Gap
Thread Diameter
property of sparkplugs.com

CHART OF ELECTROMAGNETIC RADIATIONS

CHARACTERIZED BY A COMMON SPEED IN A VACUUM

VELOCITY = FREQUENCY × WAVE LENGTH
$v = n \times \lambda$

ENERGY = PLANCK'S CONSTANT × FREQUENCY
$E = h\,(6.623 \times 10^{-27}) \times n$

SPEED OF LIGHT (C) = 299,774 km. per sec. = (Approximately) 186,000 Miles per sec.

AS DETERMINED BY A. A. MICHELSON

ARTHUR H. COMPTON

W. M. WELCH SCIENTIFIC COMPANY

EMITTERS

ALTERNATING CURRENT

LONG WAVE RADIO

BROADCASTING RADIO

SUN

GAMMA RAYS

RADIUM RAYS

URANIUM ATOM

COSMIC RAYS

SHORT WAVE RADIO

SPARK OSCILLATORS

VACUUM TUBE OSCILLATORS

LONG WAVE HEAT (Radiation)

SHORT WAVE HEAT (Radiation)

HYDROGEN ATOM

ULTRA-VIOLET LAMP

X-RAY TUBE

RADIUM IN THE HOSPITAL

PRODUCTION OF X-RAYS

NUCLEUS

VISIBLE SPECTRA

FREQUENCY RANGE (WAVES PER SECOND)

TO LOWER FREQUENCIES ← → TO HIGHER FREQUENCIES

ELECTRIC WAVES | RADIO WAVES | INFRA-RED | VISIBLE | ULTRA-VIOLET | X-RAYS | GAMMA RAYS | SECONDARY COSMIC RAYS

WAVE LENGTH RANGE (IN CENTIMETERS)

TO LONGER WAVES ← → TO SHORTER WAVES

METHOD OF MEASURING THE WAVE LENGTH — ELECTRICAL RESONANCE — GRATING — INTERFEROMETER — CRYSTAL REFLECTION — QUANTUM RELATION

WAVE CHARACTERISTICS

REFLECTION

LAW OF REFLECTION

IMAGE POSITION GIVEN BY:

CONCAVE AND CONVEX MIRRORS

REFRACTION

DUE TO CHANGE IN VELOCITY OF WAVE ON ENTERING NEW MEDIUM

LENSES

IMAGE POSITION GIVEN BY:

DIFFRACTION

OCCURS WHEN WAVE FRONT ENCOUNTERS AN OBSTACLE; CRUCIAL TEST FOR WAVES

INTERFERENCE

PRODUCED BY TWO WAVES OF SAME VELOCITY AND WAVE LENGTH TRAVELING IN OPPOSITE DIRECTIONS, OFTEN PRODUCED BY USING INCIDENT AND REFLECTED WAVES

INTERFEROMETER

POLARIZATION

MECHANICAL ANALOGY OF POLARIZATION

POLARIZATION BY REFLECTION

ELECTROMAGNETIC WAVES CAN BE POLARIZED

This is proof that they are transverse waves. Unpolarized light has its vibration in every direction.

The polarizing apparatus in tests out of this multitude of directions some particular one.

DOPPLER'S PRINCIPLE

CHANGE IN FREQUENCY AND WAVE LENGTH DUE TO MOTION OF SOURCE OR MOTION OF OBSERVER

DOPPLER EFFECT DUE TO ROTATION OF THE SUN

TRANSMITTERS — RADIO ALLOCATIONS — RADIO RECEIVING

RADIO SPECTRUM: FREQUENCY and WAVE LENGTH ALLOCATIONS

AERONAUTICS
AMATEUR
BROADCASTING
DIRECTION FINDING
FIXED
MARITIME
MOBILE
RADIO BEACON
EXPERIMENTAL

FREQUENCY — IN KILOCYCLES PER SEC.
WAVE LENGTH — IN METERS

Revised Radio allocations will be found in the "Key" to this chart

ALL WAVE RECEIVER (Wave bands changed by plug-in coils)

TELEVISION RECEIVER

RADIO TUNED CIRCUIT

SUPERHETERODYNE RECEIVER

DETECTORS OF RADIO WAVES

RESO RESONATOR | LAMP INDICATOR | CRYSTAL DETECTORS | DIODE | ONE TUBE CIRCUITS | TRIODE | TETRODE | PENTODE

COHERER | THERMO-COUPLE METER | REGENERATIVE DETECTOR

RADIO CHARACTERISTICS

REFLECTION OF RADIO

REFRACTION OF RADIO

POLARIZATION OF RADIO

INTERFERENCE OF RADIO

MEASURING WAVE LENGTH WITH LECHER WIRES

FOR SHORT RADIO WAVES FROM 1 METERS TO 10 CM.

INFRA-RED

REFLECTION OF HEAT

REFRACTION OF HEAT

RADIATION OF SUN THROUGH LUMP OF ICE

INFRA-RED PHOTOGRAPHY

FILM SENSITIVE TO INFRA-RED

INFRA-RED DETECTORS

THERMOPILE | BOLOMETER

INFRA-RED SPECTRA

PASCHEN SERIES

RADIATION — TEMPERATURE

MEASUREMENT OF STAR TEMPERATURE

RANGE OF THERMOMETERS

PYROMETER

MERCURY THERMOMETER

GAS THERMOMETER

SPECTROSCOPE

BLACK BODY RADIATION

PLANCK'S RADIATION FORMULA

QUANTUM THEORY

ULTRA-VIOLET

SUN BURN

ELECTRICITY, PHOTOELECTRICITY AND PHOTOGRAPHIC EFFECTS OF ULTRA-VIOLET LIGHT

X-RAY EFFECTS

FLUORESCENCE | X-RAY PHOTOGRAPHY

X-RAY SPECTROSCOPY

CONTINUOUS AND HARSH LINE SPECTRA | FREQUENCY AND ATOMIC NO. | CRYSTAL REFLECTION OF X-RAYS

GAMMA RAYS

RADIOACTIVITY

ELECTROSCOPE

COMPTON EFFECT

CONSERVATION OF ENERGY AND MOMENTUM BETWEEN COLLISION OF X-RAY PHOTON AND ELECTRON

THE HYDROGEN SPECTRUM

WOULD APPEAR AS SHOWN BELOW THIS IS CALLED

BALMER SERIES

AND IS EMITTED WHEN AN ELECTRON FALLS FROM ORBIT 2 TO 1, 3 TO 2, ETC. SERIES LIMIT CORRESPONDS TO ELECTRON FALLING FROM OUTERMOST ORBIT (∞) TO ORBIT 2

SEE DRAWING OF HYDROGEN ATOM ABOVE.

INVISIBLE INFRA-RED

INVISIBLE ULTRA-VIOLET

EFFECT OF MAGNETIC or ELECTRIC FIELDS ON SPECTRAL LINES

FARADAY EFFECT | ZEEMAN EFFECT | STARK EFFECT

BRIGHT LINE SPECTRA OF SEVERAL ELEMENTS

STRONTIUM (Sr) | LITHIUM (Li) | SODIUM (Na)

ARGON (Ar) | HELIUM (He) | POTASSIUM (K)

CALCIUM (Ca) | BARIUM (Ba) | NITROGEN (N₂) (BAND SPECTRA)

THE VISIBLE SPECTRUM

(SOLAR SPECTRUM) (FRAUNHOFER LINES)

ULTRA-VIOLET SPECTRA (LYMAN SERIES)

WAVE LENGTH IN ANGSTROMS

PARTICLE CHARACTERISTICS

Electromagnetic Radiations Have Particle Characteristics

To each electromagnetic wave of frequency n there are associated PHOTONS of energy

ENERGY OF PHOTON $= h\,n$ (= 6.624 × 10⁻²⁷ × n) ergs

MASS OF PHOTON $= h\,n / c^2$

MOMENTUM OF PHOTON $= h\,n / c$

velocity of light 299,774 Kms/sec.

Characteristics of particles are that they are localized in space and obey the laws of conservation of energy and momentum. The PARTICLES are the PHOTONS—their effect is most pronounced for high frequency waves (X and Y radiations) than for low frequency waves (Infra-red, Radio). In the latter, wave characteristics are more pronounced.

PHOTOELECTRIC EFFECT

KINETIC ENERGY OF ELECTRONS (ejected) GIVEN BY EINSTEIN EQUATION:

$\frac{1}{2}mv^2 = hn - W$

PHOTOELECTRIC EFFECT | ELECTRON ENERGY AND THE FREQUENCY OF LIGHT DETERMINATION OF h

COSMIC RAY EFFECTS

IONIZATION CHAMBERS | ELECTROSCOPE UNDER PRESSURE

COSMIC RAY EXPLORATION

ALSO SHOWING ATMOSPHERIC PHENOMENA

APPLETON LAYER | SHORT RADIO WAVE REFLECTION | KENNELY HEAVISIDE LAYER

EARTH

Radio activity of earth discharges electroscopes. When the discharge was found to increase with elevation a new radiation called the COSMIC RAYS was discovered.

PARTICLE CHARACTERISTICS

PARTICLES HAVE WAVE CHARACTERISTICS

APPARATUS FOR DIFFRACTION OF ELECTRONS

DIFFRACTION OF WAVES (PHOTONS) | DIFFRACTION OF CORPUSCLES (ELECTRONS)

Concepts of LENGTH, MASS AND TIME — C.G.S. Units of centimeter - gram - second

LENGTH

MASS

TIME

PHOTOSYNTHESIS | VISUAL EFFECT | PHOTO CHEMICAL EFFECT | PHOTOELECTRIC EFFECT

EYE

RELATIVE VISIBILITY CURVE

PHOTOELECTRIC CELL