ELECTROMAGNETIC WAVES AND HEAT TRANSFER

SENSITIVITIES TO GOVERNING VARIABLES IN EVERYDAY LIFE

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by
M. Kemal Atesmen

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Preface

Electromagnetic waves generate radiation energy and they play very significant roles in our lives. Electromagnetic waves are studied in almost every scientific field from astronomy, agriculture, chemistry, medicine to physics. This book focuses on heat transfer aspects of electromagnetic waves. There are twenty-four chapters in this book with their solutions to heat transfer from electromagnetic waves' radiation energy with different uses and problems related to our lives. Each problem solution also investigates the sensitivity of critical independent variables to governing dependent variables.

For example, our Sun's electromagnetic waves that reach our Earth make this place livable. We are lucky to have our Sun. It is a yellow dwarf star with an average surface temperature of 5800 K and it acts like an ideal thermal radiator. Some of our Sun's electromagnetic waves reaching us on Earth can be harmful to us due to their high energy levels and others with low energy levels can be very beneficial to us. Radiation energy received from a body with a surface temperature greater than zero Kelvin can be determined by summing all the thermal radiation contributions over the entire wavelength spectrum. Radiation energy exchange between two bodies can be calculated with ease if they are perfect absorbers and emitters and their surface temperatures are known and also if the configuration factor between these two surfaces is determined. If a body is not a perfect absorber and emitter, then we have to determine emissivity of a surface as a function of surface temperature, wavelength and direction of radiation emission.

About 95 % of total solar radiation reaching Earth's surface comprises of visible and infrared regions of the electromagnetic wavelength spectrum. Remaining 5 % of total solar radiation reaching Earth's surface comprises of ultraviolet (UV) region. Exposure to solar UV radiation can have cumulative adverse effects on human health. Solar radiation that strikes our windows, swimming pools, roofs, and photo-voltaic collectors provide us free and very useful energy.

When we are cold on our patios or outside of a restaurant, a thermal radiation heater in the infrared electromagnetic wave region can warm us. In a nuclear

explosion, the fireball emits large amounts of ultraviolet, visible and infrared electromagnetic waves in the first few seconds that can devastate everything around point of burst.

Fluorescent lamps for general lighting come in different powers, sizes and phosphors to emit visible radiation energy. Our thermos bottles keep our coffees hot or our soft drinks cold mainly by reflecting electromagnetic waves between two surfaces.

In order to achieve the best paint performance for our vehicles, each layer of paint has to be cured in a bake oven according to paint supplier's bake temperature versus time specifications. Accurate control of bake temperature versus time specification is critical to the performance of a coating both physically and cosmetically. This accurate temperature control in a paint curing bake oven is obtained by laminar forced convection heat transfer and by infrared radiation heat lamps.

Even during baking a pizza, infrared electromagnetic waves from hot ceiling bricks of a hemispherical dome of a wood fired oven and by conduction heat transfer from hot bricks covering the floor are used to have a perfect pizza crust and its toppings. Microwave radiation cooking ovens are an irreplaceable component of a kitchen. Microwaves, in the electromagnetic wave spectrum, fall between the infrared radiation at the high frequency end, i.e. 300 GHz at 1 mm wavelength, and radio waves at the low frequency end, i.e. 300 MHz at 1 m wavelength.

Different bands of microwaves are used in different technologies ranging from our cell phones, garage door openers, point-to-point wireless communication links, satellite and spacecraft communications to advanced weather forecasting by providing global view of weather patterns and surface temperatures. Cosmic microwave background radiation fills the entire universe and it provides us knowledge about the beginnings of our universe, namely about the Big Bang. theory.

A radar transmits from its transmitter short pulses of electromagnetic waves at radio and microwave frequencies, i.e. 30 kHz to 100 GHz, which may be reflected by objects on their path. Reflected electromagnetic waves come back to the receiving portion of a radar system to provide information about the shape and speed of the reflecting object such as airplanes, boats, missiles, speeding cars, etc.

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I would like to dedicate this book to all engineering project teams' members with whom I had the pleasure of working together over the years, with enthusiasm, with imagination and with determination. Over these years my engineering project teams' members kept coming back to work along with me without any reservations.

M. Kemal Atesmen
Santa Barbara, California

About the Author

M. Kemal Atesmen completed his high school studies at Robert Academy in Istanbul Turkey in 1961. He received his B. Sc. degree from Case Western Reserve University, his M. Sc. degree from Stanford University, and his Ph. D. degree from Colorado State University, all in mechanical engineering. He is a life member of ASME. He initially pursued an academic and an industrial career in parallel and became an associate professor in mechanical engineering before dedicating his professional life to international engineering management and engineering project management for thirty-three years. He helped many young engineers in the international arena to bridge the gap between college and professional life in automotive, computer component, data communication, and offshore oil industries.

He published eight books, sixteen technical papers, and has four patents. His books are "Global Engineering Project Management", CRC Press, 2008, "Everyday Heat Transfer Problems – Sensitivities to Governing Variables", ASME Press, 2009, "Understanding the World Around through Simple Mathematics", Infinity Publishing, 2011, "A Journey Through Life, Wilson Printing, 2013, "Project Management Case Studies and Lessons Learned", CRC Press, 2015, "Process Control Techniques for High Volume Production", CRC Press, 2016, "Engineering Management in a Global Environment: Guidelines and Procedures", CRC Press, 2017, "Case Studies in Fluid Mechanics with Sensitivities to Governing Variables", Wiley and ASME Press, 2018, and "Nothing Is Fixed, Everything Changes", Archway Publishing, 2018.