PGRE: Studying for Death?

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Attempting to avoid death by making a big study guide!

CONTENTS

I. VARIABLE DEFINITIONS

$a \rightarrow$ acceleration

$c \rightarrow$ speed of light:
standard $\approx 3 * 10^8 \dfrac{m}{s}$

II. CLASSICAL MECHANICS (20%)

Such as kinematics, Newton's laws, work and energy, oscillatory motion, rotational motion about a fixed axis, dynamics of systems of particles, central forces and celestial mechanics, three-dimensional particle dynamics, Lagrangian and Hamiltonian formalism, noninertial reference frames, elementary topics in fluid dynamics.

III. ELECTROMAGNETISM (18%)

Such as electrostatics, currents and DC circuits, magnetic fields in free space, Lorentz force, induction, Maxwell's equations and their applications, electromagnetic waves, AC circuits, magnetic and electric fields in matter.

A. Electric Displacement Field

On the shallow level the **Electric Displacement** is the equivalent of an electric field in a media. Specifically it is defined as:

$$\vec{D} \equiv \epsilon_0 \vec{E} + \vec{P},$$

where $\vec{E}$ is the **electric field**, ϵ_0 is the **vacuum permittivity**, and $\vec{P}$ is the **polarization**. Importantly the electric displacement appears in the in-media version of Maxwell's equations. Specifically,

$$\nabla \cdot D = \rho_f,$$

where ρ_f is the **free charge density**, that which is not the **bound charge density**. We can prove this by first noting that ρ_f and ρ_b are two complementary subsets of the total charge density ρ i.e.

$$\rho = \rho_f + \rho_b.$$

next we not that the bound charge density is given by:

$$-\nabla \cdot \vec{P} = \rho_b.$$

From this we get,

$$\begin{aligned} \nabla \cdot \vec{E} &= \frac{\rho}{\epsilon_0} \\ &= \frac{1}{\epsilon_0}\left(\rho_f - \nabla \cdot \vec{P}\right) \\ \nabla \cdot \left(\epsilon_0 \vec{E} + \vec{P}\right) = \cdot \vec{D} &= \rho_f. \end{aligned}$$

if we limit ourselves to linear dielectrics according to the big G (or to wikipedia a linear, homogenous, isotropic dielectric with instantaneous response to changes in the electric field) we can define the polarization as:

$$\vec{P} = \epsilon_0 \chi \vec{E}.$$

where χ is the **electric susceptibility** of the material. Now we define for our convenience and sorrow

$$\epsilon_r \equiv 1 + \chi,$$

the **relative permittivity** of the material and

$$\epsilon = \epsilon_0 \epsilon_r,$$

the **permittivity** of the material such that

$$\vec{D} = \epsilon \vec{E}.$$

IV. QUANTUM MECHANICS (12%)

Such as fundamental concepts, solutions of the Schrdinger equation (including square wells, harmonic oscillators, and hydrogenic atoms), spin, angular momentum, wave function symmetry, elementary perturbation theory.

V. THERMODYNAMICS AND STATISTICAL MECHANICS (10%)

Such as the laws of thermodynamics, thermodynamic processes, equations of state, ideal gases, kinetic theory, ensembles, statistical concepts and calculation of thermodynamic quantities, thermal expansion and heat transfer.

VI. ATOMIC PHYSICS (10%)

Such as properties of electrons, Bohr model, energy quantization, atomic structure, atomic spectra, selection rules, black-body radiation, x-rays, atoms in electric and magnetic fields.

VII. OPTICS AND WAVE PHENOMENA (9%)

Such as wave properties, superposition, interference, diffraction, geometrical optics, polarization, Doppler effect.

VIII. SPECIALIZED TOPICS (9%)

Nuclear and Particle physics (e.g., nuclear properties, radioactive decay, fission and fusion, reactions, fundamental properties of elementary particles), Condensed Matter (e.g., crystal structure, x-ray diffraction, thermal properties, electron theory of metals, semiconductors, superconductors), Miscellaneous (e.g., astrophysics, mathematical methods, computer applications)

IX. SPECIAL RELATIVITY (6%)

Such as introductory concepts, time dilation, length contraction, simultaneity, energy and momentum, four-vectors and Lorentz transformation, velocity addition.

X. LABORATORY METHODS (6%)

Such as data and error analysis, electronics, instrumentation, radiation detection, counting statistics, interaction of charged particles with matter, lasers and optical interferometers, dimensional analysis, fundamental applications of probability and statistics.