MM2090

Assignment 4

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1 Introduction

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2.1 Snell's Law

Snell's law [4] is a formula used to explain the change in angle of movement of light when it passes through a surface bettween two differnt mediums. While the law is named after Willebrord Snellius, it was first accurately described by Ibn Sahl over 600 years before Willebrord Snellius It states that the sines of angles of incidence nd refraction is equivalent to the ratio of velocity in medium or equivalent to reciprocal of the indices of refraction.

2.2 Snell's Law equation

$$\frac{\sin(\theta_2)}{\sin(\theta_1)} = \frac{\nu_2}{\nu_1} = \frac{n_1}{n_2} \tag{1}$$

2.3 Terms in Snell's Law equation.

The terms in the equation are

- θ_1 - The angle of incidence (angle measured from the normal to the incident light)
- θ_2 - The angle of refraction (angle measured from the normal to the refracted ray)
- ν_1 - Velocity of light in the incident medium
- ν_2 - Velocity of light in the refraction medium
- n_1 - Refractive index of incident medium
- n_2 - Refractive index of refraction medium

2.4 Importance of Snell's Law

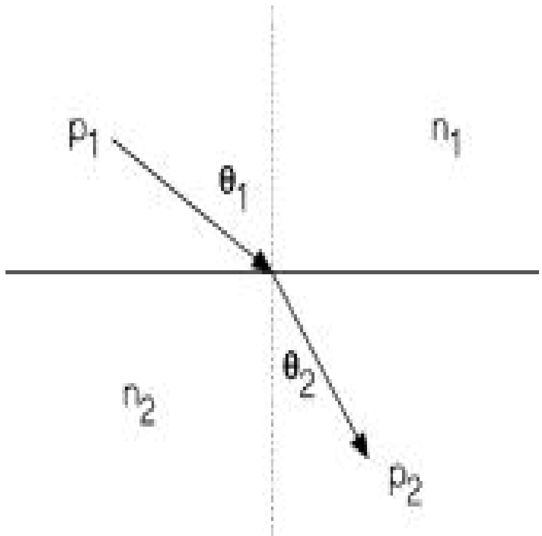

Figure 1: Light changes its direction of propogation as it passes through an interface of two diffrent medium

Snell's Law serves as backbone for Optics and related studies, with every application of refractive optics relying on this formula. It can predict the movement of light thorugh surfaces (refer fig.(1)) and this has led to countless applications. It is used while making lens for spectacles and experimental purposes.

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A Markov decision process [6] can be described as a tuple $\langle S, A, T, R\rangle$, where

- S is a finite set of states of the world;
- A is a finite set of actions;
- $T : S \times A \to \Pi(S)$ is the *state-transition function*, giving for each world state and agent action, a probability distribution over world states (we write $T(s, a, s')$ for the probability of ending in state s', gievn that the agent starts in state s and takes action a);
- $R : S \times A \to \mathbb{R}$ is the reward function, giving the expected immediate reward gained by the agent for taking each action in each state (we write $R(s, a)$ for the expected reward for taking action a in state s);
- A stationary policy, $\pi : S \to A$, is a situation-action mapping that specifies, for each state, an action to be taken.
- $V_\pi(s)$ is the expected discounted sum of future reward for starting in state s and executing policy π.

In this model, as described by figure 2, the next state and the expected reward depend only on the previous state and the action taken; even if we were to condition on additional previous states, the transition probabilities and the expected rewards would remain the same. This is known as the Markov property.

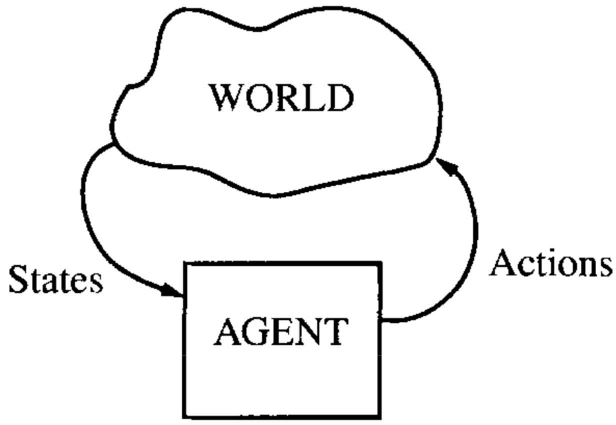

Figure 2: An MDP models the synchronous interaction between agent and world

3.1 The Value Function

$$V_\pi(s) = R(s, \pi(s)) + \gamma \sum_{s' \in S} T(s, \pi(s), s') V_\pi(s') \tag{2}$$

3.2 The Optimal Policy

Given the Value Funcition 2 a greedy policy with respect to that value function, π_V, is defined as

$$\pi_V(s) = \operatorname*{argmax}_a \left[R(s, a) + \gamma \sum_{s' \in S} T(s, \pi(s), s') V(s') \right] \tag{3}$$

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$$\nabla \times \vec{B} = \mu_0 \vec{B} + \mu_0 \epsilon_0 \frac{\partial \vec{E}}{\partial t} \tag{4}$$

Eqn. 4 is commonly known as Maxwell's fourth electromagnetic equation. It is an expansion on Ampère's Circuital Law and is hence also known as the Ampère-Maxwell Law. Currently a more generalized form is used, which takes into account the behaviour and interference of material substances in eletric and magnetic fields [5].

4.1 Terms used in the equation

- $\nabla\times$ - Curl Operator
- $\vec{B}$ - Magnetic Field Vector
- $\vec{J}$ - Current Density Vector
- $\vec{E}$ - Electric Field Vector
- μ_0 (Constant) - Permeability of Free Space
- ϵ_0 (Constant) - Permittivity of Free Space

It is an important equation as it links two phenomena, which were previously thought to be separate, magnetism and electricity. It also finally proved that light is an electromagnetic wave, (as seen in Fig. 3 taken from a paper by J. Gratus, M.W.McCall and P.Kinsler [5]) leading to a whole new area and direction of research.

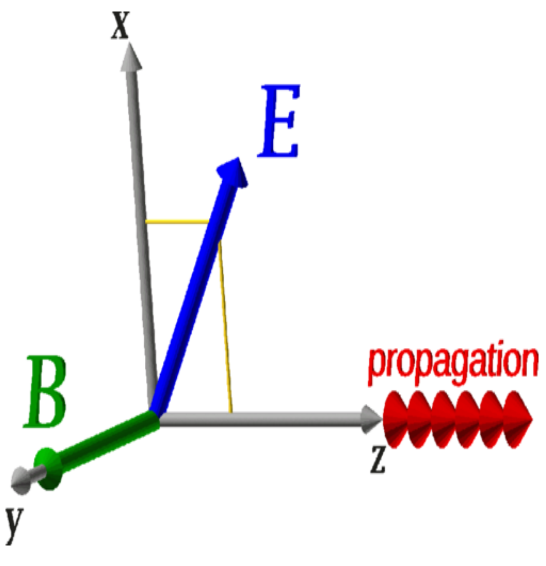

Figure 3: Propogation of Light with respect to magnetic and electric fields

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5.1 The Equation

The Coulombs Law :

$$F = \frac{Kq1q2}{r^2} \tag{5}$$

5.2 Analysis

Following contains a brief explanation of the variables and the importance of the equation :

The above given equation 6 has terms **F** ,**K** , **q1**,**q2** and **r**.

Here,

F represents the force exerted by m1 on m2 or vice versa
K represents the Coulombs Constant
q1 represents the Charge of entity 1
q2 represents the Charge of entity 2
r represents the distance between entity 1 and entity 2

Coulomb's law, or Coulomb's inverse-square law, is an experimental law[1] of physics that quantifies the amount of force between two stationary, electrically charged particles. The electric force between charged bodies at rest is conventionally called electrostatic force or Coulomb force.The law was first discovered in 1785 by French physicist Charles-Augustin de Coulomb, hence the name. Coulomb's law was essential to the development of the theory of electromagnetism, maybe even its starting point, as it made it possible to discuss the quantity of electric charge in a meaningful way.

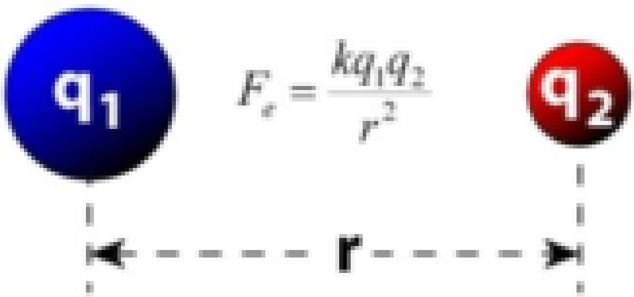

Figure 4: The Coulombs Law[1]

Webpage Links [2]

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6.1 Equation - Change in Internal Energy of an Ideal Gas

$$\Delta U = nC_v \Delta T \tag{6}$$

Here in equation 6

- ΔU represents the the change in internal energy in an ideal gas
- n represents the number of moles of the ideal gas
- C_v represents the molar specific heat at constant volume of the ideal gas
- ΔT represents the change in temperature of the ideal gas

6.2 Description

Thermodynamics often uses the concept of the ideal gas for teaching purposes, and as an approximation for working systems. The ideal gas is a gas of particles considered as point objects that interact only by elastic collisions and fill a volume such that their mean free path between collisions is much larger than their diameter.[7] Such systems approximate the monatomic gases, helium and the other noble gases. Here the kinetic energy consists only of the translational energy of the individual atoms. Monatomic particles do not rotate or vibrate, and are not electronically excited to higher energies except at very high temperatures.

Therefore, internal energy changes in an ideal gas may be described solely by changes in its kinetic energy. Kinetic energy is simply the internal energy of the perfect gas and depends entirely on its pressure, volume and thermodynamic temperature.

The internal energy of an ideal gas is proportional to its number of moles n and to its temperature T. The temperature dependence of the change in internal energy of the ideal gas is plotted in the below graph (see figure 5) [3]

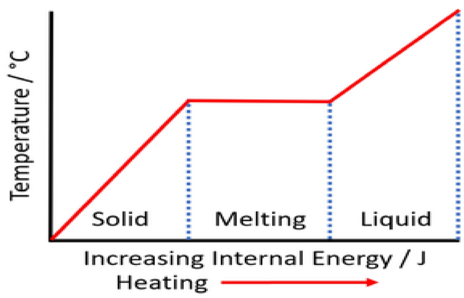

Figure 5: Internal Energy v/s Temperature graph

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[3] Internal energy v/s temperature. https://keystagewiki.com/index.php/Internal_Energy.

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