

Ministry of Higher Education and Scientific research



**Physics Department**

**College of Education**

**Salahaddin University - Hawler**

**Subject: Modern physics (first and second semester )**

**Course Book – (Year 3)**

**Lecturer's name Prof. Dr. Assad Hamid Ismail**

**Academic Year: 2022/2023**

## Course Book

|                                      |  |
|--------------------------------------|--|
| <b>1. Course name</b>                | <b>Modern physics</b>  |
| <b>2. Lecturer in charge</b>         | <b>Dr. Asaad Hamid Ismail</b>  |
| <b>3. Department/ College</b>        | <b>Physics / Education</b>   |
| <b>4. Contact</b>                    | <a href="mailto:Asaad.ismail@su.edu.krd">Asaad.ismail@su.edu.krd</a><br><b>Tel: ( 07504600048)</b>   |
| <b>5. Time (in hours) per week</b>   | <b>Theory: 3 hours/week (One group)</b>  |
| <b>6. Office hours</b>               | <b>Saturday 08:30 – 10:30, 12:30-1:30</b>  |
| <b>7. Course code</b>                |  |
| <b>8. Teacher's academic profile</b> |  |
| <b>9. Keywords</b>                   |  |
| <b>10. Course overview:</b>          | <p>Modern physics is the branch of physics which extend beyond classical physics. Modern physics contain mainly three fields which they are relativistic physics (both special and general theory of relativity), quantum physics and quantum field theory.</p> <p>This course aims to provide a third year physics major students with an introduction to modern physics and its difference from classical physics. The course begins by discussing some basic concepts and definition of modern physics and historical review of physics as general.</p> <p>Then through the chapters the student can be able to understand relativity ,postulates of Einstein, length contraction, Time dilation, black holes, atomic physics and theories and models of atoms ,radius and density of the nucleus then the spectrum of different materials. The subjects offered in this course are necessary and important and give the students a background and required knowledge which leads directly into the quantum mechanics course (offered for fourth class physics majors).</p> |

## **11. Course objective:**

### **Brief Syllabus:**

Special theory of relativity, Galilean transformation, Lorentz transformation, Lorentz-Fitzgerald length contraction, Time dialation, Doppler Effect, The expanding of the universe ,Transformation of Velocities, The Law of Conservation of Momentum, Relativistic Mass, The Law of Conservation of Mass-Energy, The Language of Physics, General theory of relativity,The Bending of Light in a Gravitational Field, The Advance of the Perihelion of the Planet Mercury, The Gravitational Red Shift, The Shapiro Experiment, The Black Hole, The Language of Physics , Quantum Physics, 1 The Particle Nature of Waves, Blackbody Radiation, The Photoelectric Effect, Failure of the Classical Theory of Electromagnetism to explain the Photoelectric Effect, Einstein's theory of the photoelectric effect, The properties of the photon, The Compton effect, The wave nature of the particles, The wave representation of a particle, The Heisenberg Uncertainty Principle, Different Forms of the Uncertainty Principle, The Heisenberg Uncertainty Principle and Virtual Particles, The Gravitational Red Shift by the Theory of Quanta, Atomic Physics , The History of the Atom, The Bohr theory of the atom, The Bohr theory and atomic spectrum, The Quantum mechanical model of the Hydrogen atom, The orbital quantum number  $L$ , The magnetic quantum number  $m_l$ , The magnetic moment of the Hydrogen atom, The potential energy of magnetic dipole in an external magnetic field, The Zeman Effect, Slection rules, Electron Spin, The Pauli exclusion principle and the periodic table of the element, Application of Physics, Is This World Real or Just an Illusion

## **12. Student's obligation**

**Grade information:** Weekly assignments (total weight 10% of grade). Midterm1 (10% of grade), Midterm2 (10% of grade) and Final exam (45% of grade)

## **13. Forms of teaching**

My lectures will follow a set of PowerPoint slides that are already in the Files section.

## 14. Assessment scheme

**Exams:** midterm 21 ( December ), midterm 24 (February) and final exam.

Exams are meant to test your understanding and ability to apply concepts covered in the course. I therefore do not expect you to memorize constants and equations. I will provide you with a sheet of relevant equations. I will give you the value of any constants you need. Although the main focus of the exams will be problem solving, all exams will likely contain one conceptual question with a written part to verify that you understand and can explain the physical concepts. Exam and homework problems will be from the textbook

## 15. Student learning outcome:

### Student Outcome Learning:

- Thinking properly and quickly of principles of modern physics.
- Getting an idea of what available before modern physics came through.
- Define both of classical and modern physics.
- Get information about special relativity and general relativity.
- Derive the equations of the Galilean Transformations of Classical Physics.
- Know that the Michelson-Morley experiment's null result implies that the all-pervading medium called the ether simply does not exist.
- Derive the Lorentz Transformation equations.
- Define both of the length contraction and time dilation and twin paradox.
- Learn about the concept of space-time and the concept of mass-energy.
- Collecting information about The Bending of Light in a Gravitational Field and black holes.
- Define matter waves and know that the waves having a nature of the particles.
- Explain the black body radiation according the quantum physics.
- Derive the Rayleigh- Jeans equation.
- Explain the photoelectric effect.
- Derive Compton scattering effect equations.
- Derive The Heisenberg Uncertainty Principle.
- Define the virtual particles.
- Determining the radius of the atoms and nucleus according to Bohr model.
- Having information about The Quantum Mechanical Model of the Hydrogen Atom

- Define Zeeman Effect.
- Explain Is This World Real or Just an Illusion

## 16. Course Reading List and References:

**Textbooks:** Fundamental of College Physics , peter J. Nolan.

Reference Books: Modern Physics, Serway, Moses and Moyer, 3rd edition, Thomson, Brooks and Cole 2005.

## 17. The Topics:

### Contents

|   |                  |
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| Chapter one: Galilean transformation<br>..... 3   | <b>( 6 hrs )</b> |
| 1.1- History of physics .....3  |                  |
| 1.2 : THE PRINCIPLE OF RELATIVITY . ..... 4   |                  |
| 1.3 The Galilean Transformations of Classical Physics . ..... 6                               |                  |
| 1.4- Galilean addition of velocities ..... 9  |                  |
| 1.5 The Invariance of the Mechanical Laws of Physics under a Galilean Transformation ..... 10 |                  |
| 1.6 Electromagnetism and the Ether ..... 14   |                  |
| 1.7 The Michelson-Morley Experiment ..... 16  | <b>12hrs</b>     |
| chapter Two: Special theory of relativity ..... 22  |                  |
| 2.1: The Postulates of the Special Theory of Relativity..... 22                               |                  |
| 2.2 The Lorentz Transformation ..... 23   |                  |
| 2.3 The Lorentz-Fitzgerald Contraction (length contraction..... 31                            |                  |
| 2.4 Time Dilation and twin paradox ..... 36   |                  |
| 2.5 Doppler effect ..... 40   |                  |
| 2.6 The Expanding Universe ..... 41   | <b>6hrs</b>      |
| 2.7 Transformation of Velocities ..... 43   |                  |
| Chapter Three: Relativistic Mass ..... 50   |                  |
| 3.1 The Law of Conservation of Momentum and Relativistic Mass .....50                         | <b>6hrs</b>      |
| 3.2 The Law of Conservation of Mass-Energy..... 56  |                  |
| 3.3 Energy of the fusion process. .... 62   |                  |
| Chapter Four: (General Relativity) ..... 67   | <b>6hrs</b>      |
| 4.1 general theory of relativity ..... 67   |                  |
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| 4.3 The Advance of the Perihelion of the Planet Mercury ..... 71                              |                  |
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| 5.2 Blackbody Radiation ..... 82  |                  |

|   |  |
|---|--|
| <p>5.4 Failure of the Classical Theory of Electromagnetism to explain the Photoelectric Effect ..... 96</p> <p>5.5 Einstein’s Theory of the Photoelectric Effect ..... 97</p> <p>5.6 The Properties of the Photon..... 101</p> <p>5.7 The Compton Effect ..... 105</p> <p>Chapter Six: The Wave Nature of Particles ..... 111</p> <p>6.1:The Wave Nature of Particles ..... 111</p> <p>6.2 The Wave Representation of a Particle ..... 113</p> <p>6.3 -The Heisenberg Uncertainty Principle ..... 117</p> <p>6.4 Different Forms of the Uncertainty Principle ..... 124</p> <p>6.5 The Heisenberg Uncertainty Principle and Virtual Particles ..... 125</p> <p>6.6- The Gravitational Red Shift by the Theory of Quanta ..... 129</p> <p>Chapter 7 Atomic Physics ..... 132</p> <p>7.1 The History of the Atom ..... 132</p> <p>7.2 Rutherford Model ..... 134</p> <p>7.3 structure of the nucleus of the atom ..... 139</p> <p>7.4 radius of the atom..... 141</p> <p>Chapter Eight : Bohr Theory ..... 146</p> <p>8.1 The Bohr Theory of the Atom ..... 146</p> <p>8.2 The Bohr Theory and Atomic Spectra ..... 152</p> <p>Chapter Nine: Quantum Model ..... 157</p> <p>9.1 The Quantum Mechanical Model of the Hydrogen Atom.....157</p> <p>9.2 The orbital Quantum number L ..... 159</p> <p>9.3 The magnetic quantum number <i>ml</i> ..... 161</p> <p>9.4 The Magnetic Moment of the Hydrogen Atom .....163</p> <p>9.5 The potential energy of magnetic dipole in an external magnetic field ..... 167</p> <p>9.6 The Zeeman Effect ..... 169</p> <p>9.7 Selection Rules..... 175</p> <p>9.8 Electron Spin ..... 175</p> <p>9.9- The Pauli Exclusion Principle and the Periodic Table of the Elements ..... 181</p> <p>Chapter Ten: Application of Physics ..... 196</p> <p>10-1: Is This World Real or Just an Illusion? ..... 196</p> | <p><b>6hrs</b></p> <p><b>6hrs</b></p> <p><b>6hrs</b></p> <p><b>( 12 hrs )</b></p> <p><b>3hrs</b></p> |
| <p><b>18. Practical Topics (If there is any)</b></p>  |  |
| <p><b>19. Examinations:</b><br/> <i>Example: Chose the correct answer for question</i><br/>                     1-Einstein's Second Postulate of Special Relativity states that the speed of light.</p>   |  |

(a) can increase if the speed of the light source increases.

(b) is constant regardless of the speed of the observer or the light source

(c) can decrease if the speed of the observer decreases

(d) randomly changes depending upon its original light source

## **2. Mathematica derivation**

A man on the earth measures an event at a point 5m from him at a time of 3sec. if a rocket ship flies over the man at a speed of  $0.6c$ , what coordinate does the astronaut in the rocket ship attribute to this event?

**3. Define the following:**

1-length contraction    2- invariant quantity    3-rest mass    4- relativistic mass

## **4. Drive:**

prove mathematically that K factor in Lorentz transformation is equal to

$$\sqrt{1 - \frac{v^2}{V^2}}$$

## **20. Extra notes:**

## **21. Peer review**

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