0REPUBLIC OF RWANDA

MINISTRY OF EDUCATION
NATIONAL CURRICULUM DEVELOPMENT CENTRE (NCDC)

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ADVANCED LEVEL PHYSICS CURRICULUM FOR SCIENCE COMBINATIONS

- MPG (Mathematics-Physics-Geography);
- PCB (Physics- Chemistry-Biology);
- PCM (Physics-Chemistry-Mathematics).
- MPC (Mathematics-Physics-Computer science)

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1. INTRODUCTION

Rwanda intends to build a knowledge based economy, with particular emphasis on science and technology as an engine of development. In this regard, the Ministry of education undertook the 2009 education system reform in which the system of combinations at advanced level was introduced. In this context, the NCDC found it wise to review Physics curriculum, the 1999 edition. In this revision, the emphasis was put on the structure of the curriculum, content and methodology in order to equip learners with enough and appropriate knowledge, skills and attitudes.

To meet this pedagogical orientation/need, the curriculum is presented in a three column table. The content suggested in the second column of the curriculum, has specific objectives to be attained in the first column as well as a methodological note in the third column which suggests the appropriate teaching/ learning activities to be done.

Physics is a science subject and directly linked to our everyday life activities thus its mastery requires scientific research and experiments. The curriculum strongly emphasises on the student practical work (laboratory experiments), project work (research work) as well as study tours. All these learning activities should give learners the opportunity to apply Physics in different contexts, and appreciate the relevance of Physics in our daily life.

This curriculum also helps learners to use ICT (Information and Communication Technology) tools to support the mastery and achievement of the desired learning objectives. Technology used in the teaching and learning of Physics, for example simulation on computer, is to be regarded as a tool to enhance the teaching and learning process and not to replace teachers.
At the end of detailed content of each grade, there is a proposal of lesson distribution to be taught per term.

2. GENERAL ORIENTATION

2. GENERAL OBJECTIVES BY THE END OF A' LEVEL

After the completion of Physics course in Advanced Level Secondary Education, the learner should be able to:

a) Apply acquired knowledge, skills and attitudes in daily life problem solving;

b) Express him/herself fluently in teaching language: written and spoken;

c) Analyze situations scientifically;

d) Analyze, explain facts and practical applications of phenomena relating to daily life;

e) Identify scientific problems;

f) Collect, evaluate and interpret scientific data;

g) Present results and draw appropriate conclusions;

h) Possess knowledge and skills that would enable him /her to access studies in Physics and related courses in universities and higher institutions of learning;

4. LEARNERS' SKILLS TO BE IMPROVED

Skills	**Main learning activities**
Use ICT knowledgably and effectively	– Writing report using computer – Studying Physics using interactive multimedia material – Using experiments simulations – Doing research using available technological facilities of information accessibility
Work independently and in a team with minimum supervision	– Doing individual work – Participating actively in team group discussion
Time management skills	– Doing his/her own planning – Following and respecting the timetable and scheduled activities.
Think logically, creatively and critically	– Thinking logically in problem solving, – Being creative in concept application – Thinking critically about an observation – Having scientific reasoning.
Communicate effectively	– Demonstrating scientific report writing skills – Writing a good report on experiment performed in class/laboratory – Leading group discussions – Participating actively in group discussions – Communicating clearly a scientific concept
Demonstrate an organizing ability	– Organizing and planning activities – Explaining the plan – Leading group discussions – Leading group activities – Following-up the realization of the planned activities – Adjusting the plan depending on the results and remarks from the follow-up

Skills	**Main learning activities**
Demonstrate knowledge of basic laboratory skills (lab precautions and hands on activities)	– Paying much attention on lab safety rules and precautions, – Reading the experiment guideline, – Select the required lab materials, – Reading the notice and tags of lab materials before using it, – Using the right lab equipment in experiment, – Doing experiment and interpret the results, – Rearranging the lab materials in the right place.
Make a presentation on a given science related topic	– Doing a research – Doing a report – Calling out and explaining clearly the results from the research

5. METHODOLOGICAL NOTES

The use of teaching resources is crucial in enabling learners to understand Physics concepts.
Teachers should encourage learner's hands–on activities using real or concrete materials to help them gain experience, construct abstract ideas, obtain scientific findings, build self confidence, be independent and inculcate the spirit of cooperation.

In order to assist learners in having positive attitudes towards Physics, confidence and thinking systematically, students have to be involved into the teaching and learning process. Good moral values can be cultivated through suitable contexts. Learning in groups should be emphasized to help learners to develop social skills, encourage cooperation and build self confidence. Environment awareness and conservation skills should also be developed through the teaching and learning process in the classroom by using various examples. Various teaching strategies and approaches such as direct instruction, discovery learning, investigation, guided research or other methods must be incorporated**.** Among the approaches that should be taken into consideration, we can say:

- Learner-centered learning;
- Different learning abilities and styles of learners (individualization);
- Use of relevant, suitable and effective teaching materials;
- Formative evaluation to determine the effectiveness of teaching and learning process.

The choice of a suitable approach will stimulate the teaching and learning environment inside or outside the classroom. The considered suitable approaches include the following:

- Cooperative learning;
- Contextual learning;
- Mastery learning;
- Constructivism.

In this curriculum, suggested various exercises in all chapters may be done in groups or individually.

6. EVALUATION APPROACH

Evaluation or assessment has to be planned and carried out as a part of the classroom activities. Different methods of assessment can be conducted. These may be in the form of assignments, oral questioning and answering, observations and interviews. Based on the given responses, teacher can rectify learners' misconceptions and weaknesses and also improve his/her own teaching skills. Teacher can then take subsequent effective measures in conducting remedial and enrichment activities in upgrading learners' performances.

The teacher should organise practical tests to verify whether students have indeed acquired the basic skills suggested in this curriculum: He/she should set standards of passing these tests. It is not recommended to evaluate students on the basis of technical terms; it is the student's reasoning that matters.

7. PROGRAMS

7.1. PROGRAM FOR SENIOR 4

GENERAL OBJECTIVES BY THE END OF S4
At the end of senior 4, the learner should be able to:

- Demonstrate the working of various optical instruments,
- Solve problems related to geometrical optic, electricity and kinematics,
- Draw and interpret diagrams and graphs related to geometrical optic, electricity and kinematics,
- Analyze the problems and explain the phenomena of geometrical optic, electricity and kinematics,
- Collaborate with colleagues in order to develop a team spirit,
- Demonstrate the awareness of the nature of science, the structure and objectives of the physics course.

PART.I : GEOMETRIC OPTICS

CHAPTER I: REFLECTION AND ITS APPLICATIONS

General objectives: At the end of this chapter, the learner should be able to:

- Use different types of mirrors and apply the laws of reflection in daily life situations

Specific objectives	**Content**	**Learning activities**
At the end of this chapter, the learner should be able to: • Recognise the phenomenon of reflection • Use a plane mirror to solve specific practical problems	1.1 Review on Light propagation in straight line 1.2 Light reflection • Laws of light reflection • Reflection of light on plane mirror • Regular reflection and diffusion of light • The law of reversibility of light	▪ Answer questions about linear propagation of light ▪ Observe reflection of light on plane mirrors ▪ Construct graphically images of objects in

Specific objectives	Content	Learning activities
• Solve some problems relating to light propagation in straight line • State the effects of translation and rotation of a plane mirror • Use Fermat principle to obtain the laws of reflection and refraction • Perform experiments of multiple reflection of light from plane mirrors • Interpret experimental results of multiple reflection • Solve problems related to reflection of light from plane mirrors • Describe a spherical mirror • Determine the image formed by graphical method • Establish the formula of spherical mirrors • State the sign convention • Solve problems related to reflection of light in spherical mirrors • Utilise a spherical mirror to solve specific practical problems • State the defects of spherical mirrors • Use cylindrical and parabolic mirrors to solve practical problems	• Formation of real and virtual image of an object • Translation and Rotation of plane mirror • Inclined mirrors and multiple images • Spherical mirrors: • Curved mirrors description • Properties of Reflection on spherical mirrors (concave and convex) • Graphical construction of images of objects in spherical mirrors • The mirror formula • Practical application of curved mirrors • Spherical aberrations 1.3 Other types of curved mirrors: • Cylindrical mirrors • Parabolic mirrors	plane mirror ▪ Deduce properties of the formed image ▪ Establish experimentally the laws of reflection ▪ Establish experimentally the formula of rotation of plane mirror ▪ Observe multiple images formed by inclined mirrors ▪ Give a description of convex and concave mirrors specifying geometrical elements and construct images geometrically (homework) ▪ Perform experiments and establish the formulae mathematically ▪ Observe cylindrical and parabolic mirrors ▪ Discuss in group work the use of cylindrical and parabolic mirrors ▪ State instruments which use curved mirrors

CHAPTER II : REFRACTION

General objectives: At the end of this chapter, the learner should be able to:

- demonstrate knowledge and understanding of the phenomenon of refraction and its laws

Specific objectives	**Content**	**Learning activities**
• State the laws of refraction • Recognise the phenomenon of refraction • Explain the phenomenon of total internal reflection • Explain apparent depth • Solve problems involving refraction • Describe the parallel plan surfaces • Determine the displacements of rays through the parallel plan surfaces • Solve problems involving parallel plane surface • Describe a prism • State prism formulae • Utilise a prism for: -measuring refractive index o analysing a beam of light • Solve problems related to a prism • Describe a lens • Give the properties of lenses • State types of lenses	2.1. Description of the phenomena of refraction 2.2. Laws of refraction and its applications • Laws of refraction • The real and apparent depth • The critical angle • Total internal reflection and its practical application • Refraction through the Parallel plane • surfaces 2.3. Refraction through prisms • Terms associated with refraction through a prism • Deviation of a ray of light by a glass prism • Angle of minimum deviation and the measurement of refractive index • Dispersion of light by a prism • Application: Total reflecting prism 2.4 Spherical lenses • Types of lenses • Geometrical terms of spherical thin lens	▪ Observe refraction of light ▪ Establish experimentally the laws of refraction ▪ Determine the refractive index of medium ▪ Determine experimentally the critical angle of refraction ▪ Observe and describe a prism ▪ Measure refractive index using a prism ▪ Analyse a beam of light using a prism ▪ Observe and describe different types of lenses ▪ Observe the action of lenses on a parallel beam of light ▪ Find experimentally the image position by a lens ▪ Construct geometrically images formed by

Specific objectives	Content	Learning activities
• Determine experimentally the focal length and the position of focal point of lens • Establish the lens formulae • State the sign convention of lenses • State the defects of lenses and how they occur	• Images formed by converging and diverging lenses • Graphical construction of images formed by converging and diverging lenses • The lenses formula • Magnification in lenses • The power of lenses • Defects of lenses: chromatic and spherical aberration	different lenses ▪ Establish experimentally the formulae of lenses. ▪ Determine experimentally the focal length of a lens.

CHAPTER III : SOME OPTICAL INSTRUMENTS

General objectives: At the end of this chapter, the learner should be able to:

– Use and explain the operational principle of some optical instruments

Specific objectives	Content	Learning activities
• Draw a diagram of an eye, photographic camera, slide projector, microscope and astronomical telescope to show how they function • Calculate magnification and power of a microscope	3.1. Simple optical instruments: Human eye, Magnifying glass, Camera and slide projector 3.2.Compound optical instruments: • Microscope and Telescope • Magnifying power of these instruments	▪ Use a microscope to observe cells on a permanent slide ▪ Use a magnifying glass to observe small objects ▪ Simulate the correction of the myopia and hypermetropia by associating lenses

PART II : ELECTROSTATICS AND DIRECT CURRENT ELECTRICITY

CHAPTER I : ELECTROSTATICS

General objectives: At the end of this chapter, the learner should be able to:

- demonstrate knowledge and understanding of static electricity
- describe and use capacitors in electric circuits

Specific objectives	**Content**	**Learning activities**
• Describe electrostatic charging of materials • State the two types of charges • State coulomb's Law • Draw electric field patterns • Distinguish between conductors and insulators • Explain charge distribution on conductors of various shapes • State the principle of superposition • Define flux of an electrical field through a surface o Deduce Gauss's theorem • Define electrostatic potential and	1.1. Electrification by: Friction ; contact and induction 1.2. Distribution of charge on the surface of a conductor 1.3. Electric charge and coulomb's Law 1.4. The concept of electric field 1.5. Electric field patterns of lines of force • Isolated charges • Unlike charges • Like charges • Uniform electric field 1.6. Electric field due to the distribution of electric charge 1.7. Flux and Gauss's Theorem 1.8. Electrostatic potential • Electric potential energy • Potential difference • Electric potential due to point charge • Electric potential due to system of	▪ Perform experiments of charging a body by friction ▪ Observe the action between two like charges and two unlike charges ▪ Charge an electroscope by induction ▪ Charge an electroscope by contact ▪ Observe the action of points ▪ Draw field lines for a point charge ▪ Draw field lines for two like charges ▪ Draw field lines for two unlike charges ▪ Find experimentally the electric fields between two parallel plates ▪ Perform exercises on calculation of flux

Specific objectives	Content	Learning activities
bring the idea of potential difference • Establish relation between electrostatic field and potential difference • Explain how lightning arrestors work • Define capacitance • Explain the charging and discharging of a capacitor • State the factors affecting the capacitance of a paralleled plate capacitor • Determine the effective capacitance for the series and parallel arrangement • State applications of capacitors in everyday life	charges • Relationship between electrostatic field and potential difference • Lightning and lightning arrestor 1.9.Capacitors • Capacitance of capacitor • Types of capacitors • Parallel plate capacitor • Variable air capacitor • Electrolytic capacitor • Arrangement of capacitors (series and parallel) • Qualitative treatment of charging and discharging capacitors • Energy of charged capacitor	▪ Calculate electric potential ▪ Observe and describe different types of capacitors ▪ Arrange the capacitors in series and parallel ▪ Establish formulae of capacitors in series and in parallel

CHAPTER II : DIRECT CURRENT ELECTRICITY

General objectives: At the end of this chapter, the learner should be able to:

- Draw and interpret diagrams and graphs related to direct current electricity
- set up electrical arrangements
- Solve problems related to direct current electricity

Specific objectives	**Content**	**Learning activities**
- Draw simple electric circuits. - Set up simple electric circuits. - Define electric potential difference. - Define the intensity of electric current. - State some sources of electric current. - Set up electric circuits involving ammeters and voltmeters. - Define electromotive force; potential difference and the internal resistance. - Apply Ohm's Law to solve problems. - Determine the effective resistance of resistors in series and in parallel. - Measure resistance. - Measure the resistivity of a material. - State Kirchoff's Laws - Determine the e.m.f; resistance; internal resistance potential difference of a combination of cells. - Define back e.m.f; internal resistance A. - Identify the charge carrier or ion and give some examples in electrolysis	2.1 Review of elements of simple electric circuits and their respective role 2.2 Potential difference : • Measurement of potential difference : The Voltmeter 2.3 Electric current (I) • Mechanism of metallic conduction: • I = nevA The ammeter 2.4 Ohm's Law 2.5 Pouillet's Law 2.6. Rheostat and potential divider 2.7 Combination of resistances (series; parallel and mixture) 2.8. Electric energy and power 2.9. Sources of electric current • e.m.f; internal resistance and potential difference a cross a Cell • combination of cells: series; parallel and Mixture 2.10. Electrical receptors • Backs e.m.f internal resistance and potential difference across a receptor	▪ Realize a simple electrical circuit ▪ Measure the electric intensity in a circuit ▪ Measure the voltage at the terminals of a resistor ▪ Realize a potential divider ▪ Establish experimentally the Ohm's law ▪ Establish experimentally the Pouillet's law ▪ Measure the voltage across a source of electrical energy with and without load ▪ Establish mathematically Kirchoff's laws

Specific objectives	Content	Learning activities
and discharge lamps - Determine the mass deposit on cathode or on anode. - Describe a cell - Give the different types of cells and accumulator - Determine the efficiency of accumulator(in energy and in charge) - Explain how electric current flows in liquids and gases	• Arrangement of receptors in series and Parallel 2.11. Kirchhoff's Laws 2.12. Electric current in liquids and gases • Electrolysis, • Faraday's law • Cells and Electrical accumulator ; • Discharge lamps	▪ Realize an electrolysis of H_2SO_4 ▪ Use Faraday's law to determine the mass deposited on cathode or anode

PART III: MECHANICS I

CHAPTER I: MEASUREMENT OF PHYSICAL QUANTITIES

General objectives: At the end of this chapter, the learner should be able to:

- Measure different quantities, determine related errors and give the results in SI
- Verify formulae by using the dimensional analysis

Specific objectives	Content	Learning activities
• Define measurement of physical quantities. • Give the different types of errors • Calculate errors (sum, difference, product, quotient and root) • State the fundamental physical quantities.	• The concept of physical quantities • Fundamental and derived quantities • Vector and Scalar quantities	▪ Measure distance between 2 points using a meter rule and specify uncertainty ▪ Measure the internal and external diameter of a test tube using a vernier caliper and

Specific objectives	Content	Learning activities
• Recognize the fundamental physical quantities and the derived quantities. • State the international system of units (S.I). • Define dimension of physical quantities • Use the dimensional analysis to verify formula in physics	• The international system of units (S.I) • Dimensions of physical quantities • Measurement and types of errors	specify the uncertainty ▪ Perform exercises on dimensional analysis ▪ Determine the volume of solid with irregular shape

CHAPTER II: KINEMATICS

General objectives: At the end of this chapter, the learner should be able to:

- Solve problems related to planar motion

Specific objectives	Content	Learning activities
• Define the scope of Kinematics • Define a frame of reference • State the types of observational frame of reference • Define displacement; speed velocity and acceleration. • Distinguish scalar and vector quantities. • Determine velocity and acceleration. • Plot and interpret the graphs of motion. • Derive the equations of linear motion. • Describe the motion under gravity.	Definition of Kinematics 2.1 Concept of reference frame and frame of reference. 2.2.Motion in a straight line • Average velocity and instantaneous velocity • Average acceleration and instantaneous acceleration • Uniform motion in a straight line • Uniform acceleration • Non- uniform acceleration • Free fall	▪ Determine the speed of a person (runner) ▪ Measure the acceleration due to gravity ▪ Establish mathematically the relationship between speed, acceleration and distance. ▪ Observe different objects in circular motion ▪ Apply the equation of uniformly accelerated motion ▪ Utilize graphical methods to solve

Specific objectives	Content	Learning activities
• Use the equations of linear motion to determine the horizontal and vertical velocities of a horizontally projected object. • Determine the range; maximum height and time of vertically and horizontally projected object. • Define circular motion; angular velocity; periodic time; frequency; centripetal acceleration, linear acceleration and angular acceleration Define angular and linear acceleration.	• Determination of acceleration due to gravity by free fall method • Motion of a Projectile thrown vertically 2.3. Planar motion: • Motion of a Projectile thrown horizontally • Motion of a projectile thrown obliquely Circular Motion • Angular velocity; • Periodic time; • Frequency; • Centripetal acceleration, • Linear and angular acceleration • Uniform Circular Motion • Centripetal acceleration • Circular Motion with constant angular acceleration	problems involving uniformly accelerated motion ▪ Solve problems involving each case of projectile motion ▪ Establish the relationship between centripetal acceleration, linear or angular velocity and the radius ▪ Establish relationship between linear and angular acceleration ▪ Solve problems related to circular motion

TIME ALLOCATION S4

Content	Number of periods
Reflection and its applications	
▪ Review on Light propagation in straight line	6
▪ Light reflection	21
▪ Other types of curved mirrors	4
Refraction	
▪ Description of the phenomenon of refraction	2
▪ Laws of refraction and its applications	8
▪ Refraction through prisms	8
▪ Thin spherical lenses	9
Some optical instruments	
▪ Simple optical instruments	8
▪ Compound optical instruments	8
Electrostatics	
▪ Electrification by: Friction ; contact and induction	4
▪ Distribution of charge on the surface of a conductor	2
▪ Electric charge and coulomb's Law	5
▪ The concept of electric field	4
▪ Electric field patterns of lines of force	4
▪ Electric field due to the distribution of electric charge	3
▪ Flux and Gauss's Theorem	4

▪ Electrostatic potential	4
▪ Capacitors	10
Direct current electricity	
▪ Review of elements of simple electric circuits and their respective role	4
▪ Potential difference	2
▪ Electric current (I)	4
▪ Ohm’s Law	5
▪ Pouillet’s Law	4
▪ Rheostat and potential divider	4
▪ Combination of resistances	6
▪ Electric energy and power	4
▪ Sources of electric current	5
▪ Electrical receptors	6
▪ Kirchhoff’s Laws	8
▪ Electric current in liquids and gases	8
Measurement of physical quantities	14
Kinematics	
▪ Concept of reference frame and frame of reference.	2
▪ Motion in a straight line	10
▪ Planar motion	10

7.2. PROGRAM FOR SENIOR 5

GENERAL OBJECTIVES BY THE END OF S5

At the end of senior 5, the learner should be able to:

- Solve problems related involving conservation laws (linear momentum, angular momentum and energy)
- Establish the relationship between linear quantities and angular quantities
- Solve problems related to heat expansion and heat transfer
- Solve problems related to ideal gas laws and kinetic theory of matter
- Determine the characteristics of magnetic field created by magnet and current-currying conductors
- Collaborate with colleagues in order to develop a team spirit,
- Demonstrate the awareness of the nature of science, the structure and objectives of the physics course.

PART I: MECHANICS II

CHAPTER I : DYNAMICS OF A POINT

General objectives: At the end of this chapter, the learner should be able to:

- Solve problems involving Newton's laws of motion, linear momentum, power and energy

Specific objectives	**Content**	**Learning activities**
• State Newton's laws of motion. • Distinguish between the internal and external forces acting on a system. • Define inertia: centripetal and centrifugal forces. • State universal gravitational law.	Definition of Dynamics 1.1 Newton's laws of motion • Introduction : mass and inertia • Newton's first law of motion : the principle of Inertia • Definition of Galilean reference frames • Newton's second law of motion • Net force • Relationship between the net force and	▪ Determine experimentally the acceleration of linear motion on an inclined plane ▪ Solve problems related to each of the three Newton's laws of motion ▪ Determine experimentally the centripetal acceleration

Specific objectives	Content	Learning activities
• State the Kepler's laws. • Solve problems involving Newton's laws of motion.	acceleration ($\vec{F} = m.\vec{a}$) • Newton's third law: Principle of action and reaction 1.2.Applications of Newton's laws of motion • Motion on a horizontal plane with or without frictional forces • Motion on an inclined plane with or without friction • Force of inertia • Uniform motion in a circle: centripetal and centrifugal forces • Weightlessness • Universal gravitation law • Planetary motion and Kepler's laws	▪ Solve problems involving work, energy (potential and kinetic) and power
• Define: work; energy and power. • State the principle of conservation of mechanical energy. • Give examples of transformation of K.E. to P.E. and vice versa. • Solve problems involving; work energy, power and conservation of mechanical energy.	1.3. Work, Energy and Power • Concepts of work and energy • Kinetic and potential energy • Gravitational potential energy • Elastic potential energy • Conservation of mechanical energy • Power: Definition, formula	
• Define linear momentum.	1.4. Linear momentum • Definition of linear momentum • Conservation of linear momentum • Generalization of Newton's second law:	▪ Discover the vector nature of linear momentum ▪ Illustrate experimentally the conservation of linear momentum

Specific objectives	Content	Learning activities
• Define impulse. • Give examples of propulsion by reaction. • Distinguish between elastic and inelastic collisions. • Solve problems involving the law of conservation of linear momentum.	$\frac{\vec{dp}}{dt} = \vec{F}$ • Definition of impulse • Applications : Propulsion by reaction, recoiling gun, lawn spray • Elastic collision (head-on) • Elastic collision (not head-on) • Inelastic collision (head-on) • Explosion and defragmentation	▪ Solve problems on collisions ▪ Establish relationship between linear and angular quantities

CHAPTER II: ROTATION OF RIGID BODIES ABOUT A FIXED AXIS

General objectives: At the end of this chapter, the learner should be able to:

- Solve problems involving moments and energy in a rotational motion

Specific objectives	Content	Learning activities
• Define: moment of a force; moment of a couple; moment of inertia.	2.1. Concept of rotational motion 2.2. Moment of a force 2.3. Moment of a couple of forces • The concept of a couple • Moment of a couple • Moment of inertia (sphere, cylinder, Uniform rod, disc, ring)	▪ Solve problems involving rotational motion

Specific objectives	Content	Learning activities
• Calculate: work done by a couple. • Relate linear quantities to angular quantities. • Define: moment of a force; moment of a couple; moment of inertia.	2.4. Work done by a force acting on a rotating body 2.5. Work done by a couple 2.6. Angular momentum and its conservation 2.7. Kinetic energy of a rolling object	

CHAPTER III : STATICS

General objective: At the end of this chapter, the learner should be able to:

- solve problems related to forces in equilibrium

Specific objectives	Content	Learning activities
• State the conditions of equilibrium of solids under the action of two or more parallel forces. o State the conditions of equilibrium of solids under the action of three or more non-parallel forces. o Solve the problems involving equilibrium of objects. • Explain the equilibrium of a body on a horizontal plane; on inclined plane and when suspended. o Give concrete examples of a body in equilibrium under the actions of several concurrent	3.1. Equilibrium of solids • Conditions of equilibrium of: A body in equilibrium under the action of two or more parallel forces. Applications : The beam balance, tower crane; A body in equilibrium under the action of three or more non -parallel forces • Centre of gravity and base of support 3.2. Examples • Stable equilibrium; unstable and neutral equilibrium • Equilibrium of a body under the action of gravity: o Body on a horizontal plane:	▪ Show experimentally the three conditions of equilibrium ▪ Perform experiments for each case of equilibrium ▪ Solve problems on each case of equilibrium

Specific objectives	Content	Learning activities
forces. • Give concrete examples of a body in stable equilibrium; unstable and neutral equilibrium.	Centre of gravity and base of support o Body on an inclined plane – frictional forces o suspended object	

CHAPTER IV: FLUIDS MOTION

General objectives: At the end of this chapter, the learner should be able to:

- explain different applications of fluid flow

Specific objectives	Content	Learning activities
• Define viscosity in fluids o Determine viscosity coefficient of liquids • Draw streamlines of steady and turbulent flows o State Stoke's law o Establish Bernoulli's equation • Give applications of Bernoulli's principle (filter pump, carburetor, paint spray, aerofoils, Bunsen burner, Principle of Venturi Meter).	4.1 Viscosity 4.2 Steady and turbulent flow 4.3 Stokes' Law 4.4 Bernoulli's principle and Applications 4.5. Terminal velocity	▪ Measure terminal velocity of a ball bearing dropped into a jar of water

PART II: HEAT AND THERMODYNAMICS

CHAPTER I: THERMAL EFFECTS

General objectives: At the end of this chapter, the learner should be able to:

- Solve problems related to heat measurement and thermal expansion
- Describe the different modes of heat transfer

Specific objectives	**Content**	**Learning activities**
• Describe a thermometer. • State the materials whose physical properties varies with temperature. • Determine experimentally the specific heat capacity of a substance by: electrical method and method of mixtures. • Define linear expansion; superficial and cubic expansions. o Solve problems related to expansion. o Distinguish different modes of heat transfer o Describe the thermal energy transfer processes of conduction, convection and radiation	1.1 Difference between Heat and Temperature 1.2 .Measurement of heat: • Measurement of heat capacity and specific heat capacity by: o Electrical method o Method of mixtures 1.3 .Thermal expansion : • Linear expansion • Area expansion • Volume expansion (solid and liquid) 1.4. Modes of heat transfer • Radiation • Convection • Conduction	▪ Measure the heat capacity of a liquid using the electrical method ▪ Measure the heat capacity of a liquid using the method of mixtures ▪ Observe the linear expansion of an iron rod and a copper rod ▪ Observe the volume expansion of a liquid contained in a balloon ▪ Realize experiments showing the transfer of heat by conduction ▪ Realize experiment showing the transfer of heat by convection Realize experiment showing the transfer of heat by radiation

CHAPTER II : GAS LAWS

General objective: At the end of this chapter, the learner should be able to:

- solve problems related to perfect gas laws

Specific objectives	**Content**	**Learning activities**
○ State the physical properties that describe the behavior of an ideal gas. • Describe experiments that illustrate Boyle's law; Charles's law and pressure law. • Solve problems involving the laws of a perfect gas. • Derive the equation of a perfect gas.	2.1. Physical properties (Pressure; Volume and temperature) 2.2 .Compressibility of gases : Boyle's law ($PV = const$) 2.3.Charles's law ($\frac{V}{T} = const$) 2.4. Pressure law ($\frac{P}{T} = const$) 2.5.The equation of ideal gas ($\frac{PV}{T} = const$) The universal gas constant 2.6. Dalton's law of partial pressure 2.7. Density of gases	▪ Verify experimentally the BOYLE's law. ▪ Solve problems using gas laws equations.

CHAPTER III : LAWS OF THERMODYNAMICS

General objectives: At the end of this chapter, the learner should be able to:

- explain different applications of the first and second laws of thermodynamics

Specific objectives	**Content**	**Learning activities**
• Define internal energy and the total energy • Determine the work done by an expanding gas • State the first law of thermodynamics • Apply the first law to gases • Explain isothermal change • Explain adiabatic change • State the second law of thermodynamics • Describe the Carnot cycle • Determine the efficiency of a heat engine	. First law • Internal energy • Total energy • Work done by an expanding gas • Applications (isothermal process, isochore process, isobare process etc.) 3.2. Second law • Adiabatic change • Carnot cycle 3.3. Applications: heat engines (Carnot engine, Diesel engine, refrigeration) • Efficiency of a heat engine	▪ Visit and observe nearby heat engines ▪ Solve problems involving efficiency of heat engines ▪ Observe and describe the functioning of a fridge

CHAPTER IV : KINETIC THEORY OF MATTER

General objectives: At the end of this chapter, the learner should be able to:

- explain different applications and solve problems related to kinetic theory of matter

Specific objectives	**Content**	**Learning activities**
• Explain the properties of matter in term of the forces between molecules	3.1. Basic assumptions of kinetic theory 3.2. Forces acting between molecules	▪ Establish experimentally the Hook's law

Specific objectives	Content	Learning activities
and the energy they possess. • State Hooke's law. - Explain cohesion and adhesion phenomena - Describe the surface tension of liquid - Explain capillarity phenomenon • State the assumptions of kinetic theory of gas. • Derive the expression of internal pressure in gas • Calculate the square mean velocity of molecules in gas • Derive the equation relating the pressure of a gas with its density and the r.m.s. speed of molecules • Calculate the total internal energy of ideal gas • Obtain the equation of states for an ideal gas • Distinguish real gas from ideal gas Give the Van der Waals equation of state for real gas	3.3.SOLIDS • The nature of solids • Cohesion and adhesion • Ductility and malleability • Elasticity • Hooke's law and elastic modulus 3.4. LIQUIDS • The nature of liquids • Cohesion and adhesion phenomena • Surface tension • The shape of liquids surfaces • Capillarity 3.5. GASES • The nature of gases • Kinetic theory of gases • Kinetic and molecular interpretation of the pressure of an ideal gas • Real gas	▪ Study experimentally the surface tension by observing small liquid drops which are almost spherical ▪ Place gently a steel needle or razor blade on the surface of water and observe the flotation ▪ Observe capillarity in capillary tubes ▪ Establish mathematically the formula of pressure in an ideal gas ▪ Solve problems involving Hook's law

CHAPTER I : MAGNETIC FIELDS OF CURRENT- CARRYING CONDUCTORS (THE BIOT – SAVART LAW)

General objectives: At the end of this chapter, the learner should be able to:

- solve problems and explain different applications of magnetic field created by a current

Specific objectives	**Content**	**Learning activities**
• Demonstrate experimentally the existence of a magnetic field around a current – carrying conductor - State and explain the Biot – Savart Law • Describe the magnetic field around a wire carrying a current (straight wire, plane circular coil, solenoid) - Explain the use of electromagnets in the following applications: electric bell, loud speaker, telephone	• Magnetic field around a straight conductor • Magnetic field around a plane circular coil • Magnetic field in the centre of a solenoid • Equivalence between a bar magnet and a solenoid (Ampere hypothesis) • Applications: Electric bell .Loudspeaker .Telephone	▪ Perform qualitative experiments to observe a magnetic field created by a coil ▪ Measure magnetic field strength in the centre of a circular coil ▪ Measure magnetic field strength inside a solenoid ▪ Perform qualitative experiments to observe a magnetic field created by a solenoid ▪ Perform exercises on calculation of magnetic fields around current – carrying conductors

TIME ALLOCATION S5

Content	Number of periods
Dynamics of a point	
▪ Newton's laws of motion	6
▪ Applications of Newton's laws of motion	14
▪ Work, Energy and Power	8
▪ Linear momentum	14
Rotation of rigid bodies about a fixed axis	
▪ Concept of rotational motion	2
▪ Moment of a force	2
▪ Moment of a couple of forces	6
▪ Work done by a force acting on a rotating body	2
▪ Work done by a couple	2
▪ Angular momentum and its conservation	3
▪ Kinetic energy of a rolling object	4
Statics	
▪ Equilibrium of solids	12
▪ Examples	6
Fluids motion	
▪ Viscosity	2
▪ Steady and turbulent flow	2

▪ Stokes' law	2
▪ Bernoulli's principle and Applications	5
▪ Terminal velocity	4
Thermal effects	
▪ Difference between Heat and Temperature	2
▪ Measurement of heat	6
▪ Thermal expansion	10
▪ Modes of heat transfer	4
Gas laws	
▪ Physical properties (Pressure; Volume and temperature)	2
▪ Compressibility of gases	6
▪ Charles's law	6
▪ Pressure law	6
▪ The equation of ideal gas	4
▪ Dalton's law of partial pressure	2
▪ Density of gases	2
Laws of thermodynamics	
▪ First law	10
▪ Second law	10
▪ Applications: heat engines	8
Kinetic theory of matter	
▪ Basic assumptions of kinetic theory	2
▪ Forces acting between molecules	2

▪ Solids	10
▪ Liquids	10
▪ Gases	6
Magnetic fields of current- carrying conductors	6

7.3. PROGRAM FOR SENIOR 6

GENERAL OBJECTIVES BY THE END OF S6

At the end of senior 6, the learner should be able to:

- Apply Ampere's law, Faraday's law, Lenz's law to solve various problems related to electromagnetic phenomenon.
- Describe the characteristics of alternating voltages and currents
- Solve problems related to periodic phenomena and waves
- Determine the characteristics of Force on a current in magnetic fields
- Explain the concept of modern physics
- Collaborate with colleagues in order to develop a team spirit.

General Objectives: The aim of the lesson and experiment is to help the student investigate how the principle of electromagnetic induction.

PART I: ELECTROMAGNETISM

CHAPTER I: FORCE ON A CURRENT IN MAGNETIC FIELD.

GENERAL OBJECTIVE: By the end of this chapter students will be able to show that the magnetic force on a wire is proportional to the current in the wire and to use that force to calculate the magnetic field strength.

Specific objectives	**Content**	**Learning activities**
• Describe the motion of a charged particle in a uniform magnetic field • Determine the electron specific charge • Describe and explain a mass spectrograph • Describe and explain the cyclotron • Describe the action of a • magnetic field on a current carrying conductor • Calculate a moment of a couple acting	1.1. Force on moving charge in magnetic field • Characteristics of vector force • Trajectory of moving charge in uniform magnetic field • Measurement of the electron specific charge (e/m) using Helmholtz coils • Applications: -Mass spectrograph, -Cyclotron	▪ Observe the motion of a current carrying bar conductor in a uniform magnetic field ▪ Observe the factors influencing the orientation of the force ▪ Deduce the mathematical formula expressing the force ▪ Observe the force of interaction between two parallel current carrying conductors ▪ Establish the formula for the force

Specific objectives	Content	Learning activities
on a rectangular coil in external magnetic field. • Define magnetic flux • Give at least three practical applications of electromagnetic forces. • Explain how those application devices function. • Explain magnetic properties of matter • Define the magnetic permeability • Explain the hysteresis loop	1.2. Force on a current in magnetic field • Characteristics of vector force • Force between parallel currents • Torque on a rectangular coil in a magnetic field 1.3 Work of forces on current – carrying conductor and magnetic flux 1.4 Applications : • Cotton balance • Barlow's wheel • Moving coil galvanometer • Electric motor • Loudspeaker 1.5.Magnetic properties of matter • Magnetic permeability(μ) • Diamagnetic and Paramagnetic materials • Ferromagnetic materials -Magnetization curve -Hysteresis loop -Demagnetization	between two parallel conductors considering the fact that one of them is placed in a magnetic field created by the other. ▪ Realize a small motor with a current carrying rectangular coil in a magnetic field / (Using Barlow's wheel) ▪ Determine mathematically the work of forces on current carrying conductor in a magnetic field ▪ Measure the magnetic field in a U-magnet using the Cotton balance ▪ Observe and operate magneto-electric measuring devices (galvanometer, voltmeter, ammeter, …) ▪ Illustrate the magnetic permeability of different substances using a solenoid

CHAPTER II: ELECTROMAGNETIC INDUCTION

GENERAL OBJECTIVE: By the end of the session students will understand the principle of electromagnetic induction and the basis of Faraday's Law.

Specific objectives	**Content**	**Learning activities**
• Describe Faraday's experiment • Give the conditions of production of induced current. • State the factors that influence the magnitude of induced electromotive force. • State Faraday's law • Apply Lenz's law to determine the direction of induced current or e.m.f • Calculate the quantity of induced electric charge. • Demonstrate that mechanical energy in a rotating rectangular coil in magnetic field is transformed into electrical energy. • Explain self and mutual induction phenomena • Give at least two practical examples of induced electromotive force.	2.1. Conditions for generation of induced current 2.2 Faraday's law 2.3 Direction of induced current 2.4 Lenz's law 2.5 Magnitude of induced electromotive force (e.m.f.) 2.6 Induced current 2.7 Flux linkage 2.8 Quantity of induced electric charge 2.9 Transformation of mechanical energy into electrical energy 2.10 Induced e.m.f. and force on moving electrons 2.11 Self induction 2.12 Mutual Induction 2.13 Energy stored in a coil 2.14 Applications : • Dynamo / Alternator • Transformer • Foucault currents	▪ Realize Faraday's experiment ▪ Determine factors influencing the induced current / e.m.f ▪ Obtain mathematically the formula linking the e.m.f to the magnetic flux change rate ▪ Observe the generation of electric energy by a dynamo ▪ Observe experimentally effects of a coil a in a circuit. ▪ Observe mutual induction between two coils ▪ Observe a transformer and determine its transformation ratio (turns – ratio)

PART II: OSCILLATIONS AND WAVES

CHAPTER I: SIMPLE HARMONIC MOTION

GENERAL OBJECTIVE*:* By the end of this chapter students will be able to describe simple harmonic motion

Specific objectives	**Content**	**Learning activities**
By the end of this topic the learner should be able to : • Describe simple harmonic motion • Derive the characteristic equation of simple harmonic motion • Give examples of systems vibrating with simple harmonic motion • Determine the frequency of simple harmonic oscillators • Explain energy exchanges and its conservation in oscillating systems. • Solve problems related to simple harmonic motion. • Establish beats frequency • Use a stroboscope to determine the frequency of a vibrating system.	1.1 Kinematics and dynamics of simple harmonic motion. 1.2Examples of simple harmonic oscillators • Simple pendulum • Physical (or Compound) pendulum • Mass on a coil spring • Liquid in a U-tube • Torsional pendulum 1.5 Solution of the equation of simple harmonic motion 1.6 Energy exchanges and its conservation in oscillating systems. 1.7Superpositon of harmonic motions with same frequency • Parallel harmonic motions 1.8 Superposition of parallel harmonic motions with slightly different frequencies (beats) 1.9. Using a stroboscope.	▪ Observe the motion of oscillating systems (simple pendulum, compound pendulum, etc) and determine its characteristics ▪ Determine factors influencing the period of oscillations in different oscillating systems ▪ Establish the equation of simple harmonic motion using the second law of Newton ▪ Establish mathematically the total energy of oscillating systems ▪ Observe beats using tuning forks on resonance box ▪ Measure the frequency using a stroboscope

CHAPTER II: DAMPED AND FORCED OSCILLATIONS

GENERAL OBJECTIVE: By the end of this chapter, students will be able to understand the free oscillations of a mass and spring, how energy is shared between potential and kinetic energy, the effects of damping on oscillatory motion, how driving forces dominate oscillatory motion and the effects of resonance in oscillatory motion

Specific objectives	**Content**	**Learning activities**
• Obtain the equation of damped and forced oscillations - Analyze suggested solutions of those equations • Draw curves of damped and forced oscillations • Find the time constant τ and the quality factor of damped oscillating systems • Draw resonance curves • Explain the bandwidth and quality factor of resonating systems • Identify types of resonance • State the advantages and disadvantages of resonance.	2.1 Damped oscillations • Equation of damped oscillations and its solutions • Damping modes and their curves (lightly, heavily and critically damped oscillations) • Quality factor 2.2 Forced oscillations • Equation of forced oscillations and its solutions 2.3 Resonance • Resonance curve • Bandwidth and quality factor • Types of resonance • Advantages and disadvantages of resonance	▪ Observe the motion of oscillating systems with friction ▪ Establish the equation of damped oscillations using the second law of Newton (don't forget the friction force!) ▪ Observe the resonance phenomena ▪ Establish the equation of forced oscillations using the second law of Newton (don't forget the external force) ▪ Draw experimentally the resonance curve and determine its characteristics

CHAPTER III: ALTERNATING CURRENT

GENERAL OBJECTIVE: By the end of this chapter students will be able:

- To explain the difference between alternating current and direct current, describe the basic principles of alternating current,
- Describe the characteristics of alternating current with regard to resistance, inductance and capacitance

Specific objectives	**Content**	**Learning activities**
By the end of this topic, the learner should be able to : • Define alternating current. • Explain the production of A.C • Explain the meaning of: frequency, amplitude, and phase of an A.C. • Explain the meaning of root mean square and peak values. • Establish an equation relating root mean square and peak value for a sinusoidal A.C. • Define the impedance of an AC circuit • Give the phase relationship between current and p.d. in an AC circuit • Find impedance and phase difference between current and p.d. in various series AC circuits (using impedance diagrams). • Find impedance and phase difference between current and p.d. in various parallel AC circuits (using complex	3.1 Properties and production of alternating current 3.2 The root mean square (r.m.s) and peak values of alternating current 3.3 Relationship between the r.m.s. and peak values for a sinusoidal A.C 3.4 Characteristics of an AC circuit • Impedance • Phase difference between current and p.d. 3.5 Examples of A.C.Circuits 3.5.1. Simple circuits • R circuit • L circuit • C circuit 3.5.2 Circuit in series • RL Circuit • RC circuit • LC circuit • RLC circuit 3.5.3 Parallel circuits • RL Circuit • RC circuit • LC circuit	▪ Observe the production of a periodic e.m.f in a rectangular circuit rotating in uniform magnetic field. ▪ Measure the p.d, the frequency of an AC using oscilloscope ▪ Represent alternating current and p.d. in a phasor diagram (Fresnel Diagram) ▪ Construct a phasor diagram for the following circuits: R, L, C ▪ Construct a phasor diagram for the following circuits in series: RL, RC, LC, RLC

Specific objectives	Content	Learning activities
number method). • Calculate the average power in AC circuit • Obtain the equation of free electrical oscillations • Compare free mechanical oscillations and electrical oscillations in LC circuit • Obtain the equation of damped electrical oscillations • Compare damped mechanical oscillations with damped electrical oscillations • Establish the conditions of resonance • Determine the resonance frequency, the bandwidth and the quality factor of RLC circuit • Use an oscilloscope to measure amplitude; frequency; and phase of electrical oscillations. • Use an oscilloscope to visualize Lissajous figures	• RLC circuit 3.6 Power in A.C. circuit 3.7 Electrical oscillations • Circuits L-C. • Circuit R-L-C 3.8 Resonance in series and parallel RLC circuits • Resonance curve • Bandwidth and quality factor 3.9 Using an oscilloscope	▪ Establish mathematically impedance of the following parallel AC circuits using complex number method: RL, RC, LC, RLC ▪ Observe electrical oscillations in AC circuit using oscilloscope. ▪ Establish the equation of electrical oscillations in LC and RLC AC circuits using Kirchhoff's law ▪ Observe resonance curves using oscilloscope ▪ Observe Lissajous figures using oscilloscope

CHAPTER IV: PROPAGATION OF WAVES

GENERAL OBJECTIVE*:* By the end of this chapter students will be able to describe the propagation of waves

Specific objectives	**Content**	**Learning activities**
• Describe the wave motion • Distinguish transverse and longitudinal waves	4.1 The concept of wave 4.2 Types of waves • Transverse waves • Longitudinal waves	▪ Observe waves on a string, spring and in a ripple tank ▪ Observe the properties of waves in a ripple tank
• Give the characteristics of waves.	4.3 Characteristics of waves • Speed of waves • Wavelength • Frequency - Phase • Wave fronts	
• Explain the phenomena of reflection. • Explain the phenomena of refraction of waves. • Interpret wave patterns of diffraction.	4.4 Properties of waves • Reflection • Refraction • Diffraction	
• Establish progressive wave equation • Explain the conditions of interference. • Locate interference fringes (Constructive interference and destructive interference).	4.5. Progressive waves - Progressive wave equation - The principle of superposition 4.6. Interference of waves	▪ Establish mathematically the progressive wave equation
• Give the conditions of obtaining	4.7. Standing waves • Standing wave equations (fixed end and	

Specific objectives	Content	Learning activities
stationary waves. • Find the position of nodes and antinodes in stationary waves.	free end) - Position of nodes and antinodes - Examples of standing waves: vibrating strings.	▪ Observe interference of waves in ripple tank Observe standing waves on a vibrating string and in a sound waves apparatus

CHAPTER V: SOUND WAVES

GENERAL OBJECTIVE: By the end of this chapter students will be able to describe the sound waves and solve problems related to sound waves

Specific objectives	Content	Learning activities
• Give the characteristics of sound. • Establish relationship between characteristics of notes and sound waves • Explain beats and establish beat frequency • Explain Doppler – Fizeau effect. • Give examples of musical pipe instruments. • Establish the fundamental frequency and harmonic 2, harmonic 3,… in vibrating strings and in pipes	5.1The nature and characteristics of sound waves 5.2 Characteristics of notes - Pitch • Loudness • Timbre (or quality) 5.3 Beats 5.4 Doppler – Fizeau effect 5.5 Properties of sound waves: • Reflection, refraction, diffraction, interference 5.6. Musical instruments • Musical scales • Production of stationary sound waves: (Waves in strings, waves in pipes)	- Produce sounds with different vibrating systems (guitar, tuning fork, drum, hands, …) - Observe different characteristics of sound - Observe beats using tuning forks on a resonance box - Enumerate situations in which Doppler effect is encountered in our daily life (homework) - Observe sound properties using sound waves apparatus - Verify laws of vibration of a fixed string using a sonometer

CHAPTER VI: ELECTROMAGNETIC WAVES

GENERAL OBJECTIVE: By the end of this chapter students will be able to describe the nature of electromagnetic waves

Specific objectives	**Content**	**Learning activities**
• Explain the nature of light • Describe light interference phenomenon • Describe light diffraction phenomenon • Describe the property of light polarization. • Explain the nature of electromagnetic waves. • Give the characteristics of electromagnetic waves.	6.1 Light waves: • Interference • Diffraction • Polarization of light 6.2 Electromagnetic waves • Light and electromagnetic waves • Spectrum of electromagnetic waves	- Establish mathematically the position of light interference and diffraction fringes (Young's experiments, Fresnel mirrors, …) - Establish similarities between light and electromagnetic waves (homework) - Draw the electromagnetic waves spectrum and highlights its different parts (gamma rays, X rays, UV, Visible, IR, Radio waves, …) - Discuss the polarization property of light. - Distinguish different polarizations of light

PART III: MODERN PHYSICS

CHAPTER I: THE ATOM

GENERAL OBJECTIVE: By the end of this topic; the learner should be able to describe the structure of the atom

Specific objectives	**Content**	**Learning activities**
By the end of this topic; the learner should be able to:	1.1 Structure of atom 1.2 Energy levels and formation of spectral lines	- Observe the spectra of radiations (light) emitted by various substances, using a spectroscope.

Specific objectives	Content	Learning activities
• Describe the structure of the atom. • Explain the spectra of atomic radiations	1.3 Thermo electronic emission: Cathode rays and its applications (oscilloscope and T.V. tubes) - Electron motion in electric and magnetic fields - Fluorescence - Phosphorescence	- Discuss Rutherford and Bohr models of atom (Enumerate similarities and differences) - Discuss experimental results on hydrogen atom spectra of radiations and show their contradiction with classical physics (Balmer Series, Pfund Series, Paschen Series, …) - Discuss Bohr's quantification postulates and deduce energy levels of a hydrogen atom
• -Explain how C.R.O and T.V. tubes function. - Study the electric and magnetic deflections of electrons in cathode tubes - Distinguish fluorescent and phosphorescent materials		- Discuss thermo electronic emission (thermionic emission of electrons) phenomenon and its applications in CRO and TV tubes - Establish mathematically the deflection of electron in electric field - Establish mathematically the deflection of electron in magnetic field - Discuss the phenomenon of fluorescence / phosphorescence and its applications

CHAPTER II: LASER

GENERAL OBJECTIVE: By the end of this chapter students will be able to explain the principle of laser and give its applications

Specific objectives	**Content**	**Learning activities**
• Define a laser • Give laser properties • Explain the stimulated emission of light • Explain the spontaneous emission of light • Explain the principle and uses of Laser.	2.1 Properties of laser 2.2 Spontaneous emission of light 2.3 Stimulated emission of light 2.4 Main functions and uses of Laser 2.5 Dangers of misuse of a laser light	- Observe light laser and give its properties - Discuss spontaneous and stimulated emissions and their role in the production of laser. - Discuss applications of lasers - Discuss the potential dangers of misuse of lasers

CHAPTER III: X-RAYS

General objective: By the end of this chapter students will be able to explain the production of x-rays, as well as the operation, purpose, materials, designs, and components of x-ray tubes

Specific objectives	**Content**	**Learning activities**
• Explain the production of X-rays • State the properties of X-rays. • Explain the uses and dangers of X-rays.	3.1 Production of X-rays ; X-rays tubes 3.2 Properties of X-rays ; uses and dangers soft and hard X-rays 3.3 X-rays as part of the electromagnetic spectrum 3.4 X – rays spectra	- Draw the experimental set up for the production of X – rays (X – ray tube) - Discuss the properties of X – rays - Compare X – rays with electromagnetic waves - Discuss X – rays emission spectra - Discuss the effects and uses of X – rays

CHAPTER IV: THE PARTICLE NATURE OF LIGHT

General objective: By the end of this chapter students will be able to describe evidence for the particle nature o f light.

Specific objectives	**Content**	**Learning activities**
• Describe the photoelectric effect. • Explain the factors affecting the photoelectric emission. • Explain the application of the photoelectric effect. • Apply the equation: $E = hf$ to calculate the energy of the photoelectrons. • Apply the Einstein's formula of photoelectric effect $(hf = hf_0 + \frac{1}{2}mv^2)$ • Explain why Compton effect cannot be understood if light is only considered as a wave	4.1 Photoelectric effect : • Experimental setup and results • Factors affecting photoelectric emission; photocurrent and kinetic energy of the photoelectron • photons ; work function and Planck's constant • Applications : Photocells 4.2 Compton effect • Compton experiment • Interpretation of results • Compton wavelength	- Read the description of the photoelectric emission experiments and discuss the explanation of results (What should be the expected results if light was considered as wave? What if light is a particle?) - Discuss factors affecting photoelectric emission - Establish the formula for electrons' kinetic energy using the energy conservation law - Discuss how photocells or solar cells function - Discuss the experiment consisting in scattering of light by electrons and highlight the Compton effect - Interpret the Compton effect considering light as a wave or a particle - Establish the Compton wavelength using the laws of conservation of linear momentum and energy

CHAPTER V: ELECTRONICS

General objectives: By the end of this chapter students will be able to

- Explain the principle and state different applications of semiconductor-based components
- Explain the transmission and reception of information in telecommunication

Specific objectives	**Content**	**Learning activities**
• Distinguish between conductor, insulator and semiconductor through energy bands • Describe a semiconductor. • Distinguish between p and n types of semiconductors. • Describe voltage –current characteristics of diodes and transistors. • Explain the everyday use of junction diode and transistors. • Give practical applications of the diodes and transistors. • Give an idea of the basic terminology of communication • (using the principle of radio) • Explain the block diagram of communication	5.1. Semiconductors 5.1.1 Energy bands in solids 5.1.2 Intrinsic and extrinsic Semiconductors • Charge carriers and electron-hole • The "P" and "N" types of semiconductors formation; majority charge carriers 5.1.3 Electronic components • Junction diodes : • Junction transistors • Applications of diodes and transistors: Electric rectification; amplification; transistor as a switch, integrated circuits 5.2.Telecommunication • Representing information • Transmission of information • Amplitude modulation • Frequency modulation (FM) • Simple radio receiver and transmitter o block diagram for transmitter. o block diagram for receiver.	- Discuss energy bands in solids and characterize the conductors, semiconductors and insulators - Distinguish a semiconductors of type N and type P - Realize a circuit with junction diode and observe different phenomena when a diode is forward-biased and when a diode is reverse-biased - Realize a circuit with a diode and plot the voltage –current characteristics of a diode - Realize a circuit with a transistor and draw its characteristics. - Realize different experiments to illustrate the applications of transistors and diodes (bridge rectifier circuit, amplifier circuit). - Discuss the components used to carry electrical signals along cables in telecommunications - Participate in a study tour (Field visit)

CHAPTER VI: INTRODUCTION TO SUBATOMIC PHYSICS

General objectives: By the end of this chapter students will be able to :

- Describe fundamental and composite particles and related radiations
- Explain the fundamental interactions

Specific objectives	**Content**	**Learning activities**
• Explain the properties of different radiations • Establish the rate of decay • Give the precautions and applications of radioactivity in the life.	6.1. Radioactivity: • Properties of α, β and γ radiations • Detecting the radiations • Activity and half-life • Safety precautions • Applications	- Establish the characteristics of radiations - Establish the exponential decay rate - Discuss ways of detecting radiations - Discuss ways of protection against radiations
• Explain the concept of particle – wave duality • Establish the relationship between wave and particle properties • Distinguish between fundamental particles and composite particles • Distinguish between particles and antiparticles • State some applications for elementary particles • Compare matter and antimatter • Describe how antimatter can be used as a source of energy	6.2.Introduction to particle Physics ▪ Particle-wave duality o Relationship between energy and frequency: E = hf o Relationship between linear momentum and wave vector ▪ Fundamental particles : o Quarks; Leptons; quanta of interactions (interaction carriers) ▪ Composite particles: protons, neutrons, … ▪ Forces of interaction o Gravitation	- Discuss the nature of a particle - Establish the linear relationship between energy – impulse of a particle and its associated wave frequency and vector - Discuss characteristics of fundamental building blocks of matter

Specific objectives	Content	Learning activities
	○ Electromagnetic ○ Weak ○ Strong ▪ Classification of particles: ○ Leptons (which don't feel strong interactions: electrons, muon, tauon, neutrinos …) ○ Hadrons (which feel strong interactions: mesons, baryons) ▪ Antiparticle and Antimatter	- Discuss the forces which bind different fundamental particles into different structures - Distinguish fundamental and composite particles (Please use with precaution the term "Elementary Particles") - Enumerate main properties of particles and give corresponding classification - Discuss the concepts of matter and antimatter

CHAPTER VII: ENERGY PROBLEMS IN THE WORLD AND HOW PEOPLE TRY TO SOLVE THEM

General objective: By the end of this chapter students will be able to:

- Explain different energy transformations and suggest solutions to energy problems.

Specific objectives	**Content**	**Learning activities**
• Give different forms of energy. • Give the chain of transformation of energy in different power generation plants • Explain how different power generation plants function • Explain the relationship between mass and energy $E=mc^2$ • Assess energy needs of the world population and how they are met • Assess energy needs of the Rwandan population and suggest how they can be met	▪ Sources of energy o Classical sources o Renewable sources ▪ Transformations of energy into different forms o A hydro-electric power plant o A digester o Solar installation for cooking and lighting o Windmill o Geothermal installation o Tidal installation o A nuclear power plant o Thermal power plant o Biofuel ▪ Energy problems in the world ▪ Energy problems in Rwanda	- Discuss different forms and sources of energy - Discuss the chain of transformations of energy in different power generation plants. - Visit some power generation plants Discuss energy problems in the world/ Rwanda and suggest the solutions.

TIME ALLOCATION S6

Content	Number of periods
Force on a current in magnetic field	
▪ Force on moving charge in magnetic field	6
▪ Force on a current in magnetic field	8
▪ Work of forces on current – carrying conductor and magnetic flux	3
▪ Applications	8
▪ Magnetic properties of matter	6
Electromagnetic induction	
▪ Conditions for generation of induced current	1
▪ Faraday's law	2
▪ Direction of induced current	1
▪ Lenz's law	1
▪ Magnitude of induced electromotive force (e.m.f.)	2
▪ Induced current	1
▪ Flux linkage	1
▪ Quantity of induced electric charge	1
▪ Transformation of mechanical energy into electrical energy	1
▪ Induced e.m.f. and force on moving electrons	2
▪ Self induction	2
▪ Mutual induction	2
▪ Energy stored in a coil	2
▪ Applications	6
Simple harmonic motion	
▪ Kinematics and dynamics of simple harmonic motion	4
▪ Examples of simple harmonic oscillators	4
▪ Solution of the equation of simple harmonic motion	2
▪ Energy exchanges and its conservation in oscillating systems	2

▪ Superpositon of harmonic motions with same frequency	2
▪ Superposition of parallel harmonic motions with slightly different frequencies (beats)	2
▪ Using a stroboscope	4
Damped and forced oscillations	
▪ Damped oscillations	4
▪ Forced oscillations - Resonance	5
Alternating current	
▪ Properties and production of alternating current	3
▪ The root mean square (r.m.s) and peak values of alternating current	2
▪ Relationship between the r.m.s. And peak values for a sinusoidal A.C	1
▪ Characteristics of an AC circuit	2
▪ Examples of A.C. Circuits	10
▪ Power in A.C. circuit	2
▪ Electrical oscillations	3
▪ Resonance in series and parallel RLC circuits	6
▪ Using an oscilloscope	4
Propagation of waves	
▪ The concept of wave	2
▪ Types of waves	2
▪ Characteristics of waves	2
▪ Properties of waves	2
▪ Progressive wave	3
▪ Interference of waves	3
▪ Standing waves	3
Sound waves	
▪ The nature and characteristics of sound waves	2
▪ Characteristics of notes	1
▪ Beats	2
▪ Doppler – Fizeau effect	3
▪ Properties of sound waves	2
▪ Musical instruments	4
Electromagnetic waves	

▪ Light waves	5
▪ Electromagnetic waves	3
The atom	**5**
Laser	4
X-rays	**4**
The particle nature of light	
▪ Photoelectric effect	2
▪ Compton effect	2
Electronics	
▪ Semiconductors	13
▪ Telecommunication	5
Introduction to subatomic physics	
▪ Radioactivity	6
▪ Introduction to particle Physics	6
Energy problems in the world and how people try to solve them	**6**
▪ Revision and Exams	14
Total	**84**

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10. ANNEX: LEAVERS PROFILES

10.1. Common Leavers Profile for all Combinations:

After the completion of advanced level secondary education student should have acquired knowledge, skills and attitudes that enables him/her to:

1) Use ICT basic knowledge and skills in his/her day to day activities;
2) Express him/her self fluently in teaching language: written, speaking;
3) Show time management skill and being organised;
4) Know and correctly use the rights given by the law;

5) Carry out and help in carrying out a scientific research related to his/her education field,
6) Work in a team, have same vision and contribute towards the attainment of the intended objectives;
7) Be well oriented and very well know what he/she intends to be in the future;
8) Show good habits that protects his /her health and others' health especially against HIV/ AIDS and other diseases;
9) Develop self confidence in what he/she does and presentation skills;
10) Be self motivated and work without supervision;
11) Understand Rwandan's politics and contribute to resolution of political problems in a spirit of tolerance, liberty and justice;
12) Posses general knowledge and be realistic;
13) Contribute reasonably to the economic growth;
14) Posses knowledge, skills and attitudes that enables him/her to adapt to the changes in the Rwandan society;
15) Know and respect the human rights related to the freedom of speech;
16) Posses knowledge that would enable him/her to access studies in Universities and Higher Learning Institutions;

17) Develop him/her self and contribute to the development of his/her country, creating and managing small/ micro income generating projects adapted to local realities;
18) Avoid segregation, discrimination, genocide ideology and other bad ideologies;
19) Posses self evaluation and self confidence in the work he/she does;
20) Understand and ability to explain the relationship between person and his environment hence residing among them in appropriate way;
21) Apply learnt knowledge, skills and attitudes in daily life problem solving.

10.2. Physics– Chemistry – Mathematics (PCM)

Upon completion of advanced level secondary education in Physics– Chemistry – Mathematics (PCM), the student should have acquired basic knowledge, skills and attitudes which will enable him/her to:

1) Apply experimental, prospective and axiomatic processes;
2) Analyse, explain facts and practical applications of phenomena relating to daily life;
3) Work in a laboratory;
4) Posses appropriate attitude in usual scientific and professional situations, by improving knowledge, being realistic and self motivated;
5) Apply ordinary skills, techniques and operational methods in the resolution of problems related other subjects;
6) Collect, evaluate, interpret scientific data and present the out results
7) Have access to higher studies in higher institutions of learning and universities mainly in the following faculties:
    - Sciences
    - Engineering
    - Agricultural engineering, environmental science
    - Rural development

10.3. Mathematics-Physics-Geography (MPG)

Upon completion of advanced level secondary education in Mathematics- Physics – Geography (MPG), the student should have acquired basic knowledge, skills and attitudes which will enable him/her to:

1) Apply experimental, prospective and axiomatic processes;
2) Analyse, explain facts and practical applications of phenomena relating to daily life;
3) Work in a laboratory;
4) Posses appropriate attitude in usual scientific and professional situations, by improving knowledge, being realistic and self motivated;
5) Apply ordinary skills, techniques and operational methods in the resolution of problems related other subjects;
6) Collect, evaluate, interpret scientific data and present the out results;
7) Analyse and react towards issues sensitive to the world which have negative impact on people's lives: environmental degradation, population growth, etc. and contribute towards solving them;
8) Understand the value, maintenance and exploitation of environment;
9) Participate in research aiming at analysing geography related issues;
10) Have access to higher studies in in Higher Learning Institutions and Universities mainly in the following faculties:
    - Sciences
    - Engineering
    - Agricultural engineering, environmental science
    - Rural development

10.4. Mathematics- Chemistry- Biology (MCB) and Physics-Chemistry- Biology (PCB)

Upon completion of advanced level secondary education in Mathematics- Chemistry- Biology (MCB) and Physics-Chemistry-Biology (PCB), the student should have acquired basic knowledge, skills and attitudes which will enable him/her to:

1) Apply experimental, prospective and axiomatic processes;
2) Analyse, explain facts and practical applications of phenomena relating to daily life;
3) Work in a laboratory
4) Posses appropriate attitude in usual scientific and professional situations, by improving knowledge, being realistic and self motivated;
5) Apply ordinary skills, techniques and operational methods in the resolution of problems related other subjects;
6) Collect, evaluate, interpret scientific data and present the results;
7) Have access to higher studies in higher institutions of learning and universities mainly in the following faculties:
    - Medicine
    - Veterinary medicine
    - Sciences
    - Allied health science
    - Community health science
    - Nursing science
    - Agricultural and rural development

10.5. Mathematics - Physics - Computer science- (MPC)

Upon completion of advanced level secondary education in Mathematics- Physics – Computer Science (MPC), the student should have acquired basic knowledge, skills and attitudes which will enable him/her to:

1) Apply experimental, prospective and axiomatic processes;
2) Analyse, explain facts and practical applications of phenomena relating to daily life;
3) Work in a laboratory;
4) Have appropriate attitude in usual scientific and professional situations, by improving knowledge, being realistic and self motivated;
5) Apply ordinary skills, techniques and operational methods in the resolution of problems related other subjects;
6) Collect, evaluate, interpret scientific data and present the results;
7) Prove the principle algorithms in analysis that provides solutions related to studied subjects;
8) Use computer to Put up, maintain and control data base (data base using SQL server or others);
9) Carry out computer maintenance;
10) Put up simple networks;
11) Use appropriately programming languages (eg. C, C++, visual basic….) in analysis that provides solutions to Physics and Mathematics subjects;
12) Have access to higher studies in higher institutions of learning and universities mainly in the following faculties:
    - Sciences
    - Engineering