Republic of Rwanda
Ministry of Education

RTB | RWANDA TVET BOARD

APPLIED PHYSICS II

GENAP402

Apply Physics

Competence

RQF Level: 4

Learning Hours : 100

Credits: 10

Sector: ICT and Multimedia

Trade: Software Development and Embedded Systems

Module Type: General

Issue Date: September 2023

CURRICULUM: GENAP4002-TVET CERTIFICATE 4 – A

1200

<table>
<tr><td>Purpose statement</td><td colspan="6">This module describes knowledge, skills and attitudes required to apply concepts of mechanics, vibrations, waves, telecommunication and quantum mechanics. At the end of the module, the leaner will be able to describe laws of motion and their applications, apply statics equilibrium and elasticity, apply vibrations and waves, apply telecommunication, apply quantum mechanics.</td></tr>
<tr><td rowspan="6">Delivery modality</td><td colspan="2">Training delivery</td><td>100%</td><td colspan="2">Assessment</td><td>Total 100%</td></tr>
<tr><td colspan="2">Theoretical content</td><td>70%</td><td rowspan="4">Formative assessment</td><td>25%</td><td rowspan="4">50%</td></tr>
<tr><td colspan="2">Practical work:</td><td rowspan="3">30%</td><td rowspan="3">25%</td></tr>
<tr><td>• Group project and presentation</td><td>10%</td></tr>
<tr><td>• Individual project /Work</td><td>20%</td></tr>
<tr><td colspan="3"></td><td colspan="2">Summative Assessment</td><td>50%</td></tr>
</table>

Elements of Competency and Performance Criteria

Elements of competency	Performance criteria
1. Apply laws of motion on a point like material	1.1. Physics quantities for description of motion are properly described based on the various physical dimensions
	1.2. The linear uniform motion and the linear uniformly accelerated motion are clearly described based on their equation of motion
	1.3. Application of concepts of motion to free fall is correctly explained based on equation of motion
	1.4. Concepts of motion are clearly applied on the inclined projectiles based on equations of linear motion
	1.5. The curvilinear motion is clearly applied based on real life systems
	1.6. The application of circular motion is correctly described based on speed and centripetal acceleration
	1.7. Application of the Newton's laws of motion are properly described based on the type of applied forces
	1.8. The concepts of energy, work and power are properly explained
	1.9. Usage of Artificial intelligence tools in measurements of physics quantities is correctly described

2. Apply laws of motion on systems of particles	2.1. The concepts of mass surface geometry and moment of inertia matrix are properly described based on the system's symmetry
	2.2. The momentum and collisions are clearly applied based on conservation laws
	2.3. The motion of a system of particles and the motion of a rigid body are clearly applied based on the type engineering problems
	2.4. The Applications of Newton's law of gravitation are clearly described based on the described systems
	2.5. Application of Kepler's laws of motion of planets is properly described based on types of systems
	2.6. Applications of Newton's law to bodies with variable mass are correctly described based on types of bodies
	2.7. Computational mechanics and artificial intelligence tools are properly applied based on types problems
3. Apply Statics and material science	3.1. Laws of statics equilibrium are properly described based on Newton's laws of motion
	3.2. Applications of laws of statics are correctly described based on types of beams
	3.3. Applications of laws of statics on tresses are correctly described based on the types of engineering structurers
	3.4. Mechanical properties of materials are correctly described based on types of applied stresses
	3.5. Artificial intelligence tools for materials generation are properly used based on the types of materials
4. Apply mechanical Oscillations and Wave Optics	4.1. The applications of the mechanical oscillations are clearly described based on the types of the systems
	4.2. The wave propagation is clearly described based on the properties of waves
	4.3. The earthquake and seismic waves are clearly described based on the properties of waves
	4.4. Application of Huygens, Bragg's and Snell's laws are clearly described based on types of wave-matter interaction
	4.5. The application of the laws of Interference and polarization is clearly described in line with properties of light waves
5. Apply mobile phone and	5.1 The interpretation of concepts of communication are correctly described based on transmission system

	radio communication	5.1 Transmission signal generation is properly applied based on the types transmission system
		5.2 The optical fibre in telecommunication systems is correctly described based on transmission system properties
		5.3 Radio communication systems are correctly described based on transmission conditions
		5.4 Mobile communication systems are correctly described based on transmission conditions
		5.5 Principles of Signal and image processing are correctly applied based on their types
6	**Apply quantum mechanics**	6.1 The duality wave-particle is properly described based on the properties of particles and waves
		6.2 The measurements in quantum mechanics are correctly described based on physical quantities
		6.3 Computational physics tools are properly applied based on the quantum mechanics problems

Course content	
Learning outcomes	**At the end of the module the learner will be able to:** **1. Apply laws of motion on a point like material** **2. Apply laws of motion on systems of particles** **3. Apply Statics and material science** **4. Apply mechanical Oscillations and Wave Optics** **5. Apply mobile phone and radio communication** **6. Apply fundamentals of quantum mechanics**
Learning outcome 1: Describe laws of motion for a point like material	**Learning hours: 20**

Indicative content

- **Description of Physics quantities**
  - ✓ Position
  - ✓ Position vector
  - ✓ Displacement
  - ✓ Speed
  - ✓ Velocity
    - Average velocity
    - Instantaneous velocity
  - ✓ Acceleration
    - Average acceleration
    - Instantaneous acceleration
- **Description of the linear uniform motion and linear uniformly accelerated motion**
  - ✓ Equations of motion for a linear uniform motion
  - ✓ Equations of motion for a linear uniformly accelerated motion
  - ✓ Relative motion
- **Description of the motion of a body in free fall**
  - ✓ The acceleration due to gravity
  - ✓ Equations of motion for a body in free fall
- **Application of concepts of motion on the inclined projectiles**
  - ✓ Motion in two dimensions
    - Vertical projectile
    - Inclined projectile
- **Application of curvilinear motion to real life systems**
  - ✓ Motion in cylindrical coordinates
  - ✓ Motion in a plane
  - ✓ Frenet-base
  - ✓ Circular motion
  - ✓ Transmission chain
- **Application of the Newton's laws of motion**
  - ✓ The first Newton's law of motion
  - ✓ The second Newton's law of motion
    - The nature of forces
    - The weight
    - The normal force
    - The static friction force

- The dynamic friction force
- ✓ The third Newton's law of motion
- ✓ The free body diagrams
  - The vertical massless pulley
  - A body on inclined plane
  - Two coupled bodies on inclined plane with massless pulley
  - Two coupled bodies on inclined plane with massive pulley

- **Explanation of the concepts of energy, work, power, linear momentum and collisions**
  - ✓ Brief introduction on sources of energy in the world
  - ✓ Work
  - ✓ Mechanical energy
    - Kinetic energy
    - The potential energy
  - ✓ Energy-work theorem
  - ✓ Conservative forces and non-conservative forces
  - ✓ Conservation of mechanical energy
  - ✓ Linear momentum
  - ✓ Conservation of linear momentum
  - ✓ Impulse
  - ✓ Concept of collision
    - Elastic collision
    - Inelastic collision
    - Two-dimensional collision
- **Application of artificial intelligence to measurements of physics quantities**
  - ✓ Python modules to physics measurement and data analysis
  - ✓ Virtual 3-dimension modelling
  - ✓ Virtual bodies animation

Resources required for the learning outcome	
Equipment	Whiteboard and chalkboard, Computer, Projector, Textbooks
Materials	PPT, Markers, Flipchart
Tools	Various measuring instruments, Scientific calculator
Facilitation techniques	• Demonstration and simulation • Individual and group work • Practical exercises • Trainer guided documentation • Group discussion • Documentary research
Formative assessment methods	• Written assessment • Oral presentation • Performance assessment • Product based assessment

	• Project based assessment

Learning outcome 2: Describe the motion of a system of particles	**Learning hours: 20**

Indicative content

- **The description of the concepts of mass, surface geometry and moment of inertia matrix Mass of a system of particles**
  - ✓ Mass of a rigid body
  - ✓ Center of mass
  - ✓ The motion of the center of mass
  - ✓ The moment of inertia
  - ✓ The moment of inertia of symmetric bodies
- **The application of motion of a system of particles and the motion of a rigid body**
  - ✓ Rotation around a fixed point in the plane
  - ✓ Kinematics of a rigid body
  - ✓ Euler's angles
  - ✓ The velocity of a rigid body
  - ✓ The velocity transport formula
  - ✓ Acceleration of a rigid body
  - ✓ Rotation about a fixed axis and plane motion
  - ✓ Linear momentum and angular momentum
  - ✓ Kinetic energy
  - ✓ Dynamics of a rigid body
  - ✓ Second Newton's law applied on a rigid body: on the resultant force
  - ✓ Second Newton's law applied on a rigid body: on the resultant moment
- **The Applications of Newton's law of gravitation**
  - ✓ The gravitational force: force between two celestial bodies
  - ✓ The speed of a satellite on a circular orbit
  - ✓ The period of a satellite on a circular orbit
  - ✓ Escape speed
- **Application of Kepler's laws of motion of planets**
  - ✓ First kepler's law
  - ✓ Second Kepler's law
  - ✓ Third Kepler's law
  - ✓ Conservation of angular momentum for a body under central force
  - ✓ Equation of the trajectory of a celestial body
  - ✓ Conditions of launching a satellite
  - ✓ Celestial bodies
    - Solar system
    - Galaxies

- Clusters
- superclusters

- **Application of computational physics and artificial intelligence on problems involving Newton's and Kepler's laws**
  - ✓ Python modules to physics measurement and data analysis
  - ✓ Virtual 3-dimension modelling
  - ✓ Virtual bodies animation

Resources required for the indicative content	
Equipment	whiteboard and chalkboard, compute, projector, textbooks
Materials	PPT, Markers, internet
Tools	Various measuring instruments, Scientific calculator
Facilitation techniques	• Demonstration and simulation • Individual and group work • Practical exercise • Trainer guided documentation • Group discussion • Documentary research
Formative assessment methods	• Written assessment • Oral presentation • Project based assessment • Practical assessment

Learning outcome 3: Statics and material science	**Learning hours: 10**
Indicative content	

- **Application of Laws of statics equilibrium are properly described**
  - ✓ The moment of a force
  - ✓ The varignon theorem
  - ✓ Connectors (links) and reaction forces
    - Free connector
    - Smooth support
    - Double support
    - Pinned links
    - Pinned links on rollers
    - Rigid bar connector
    - cables connector
  - ✓ Conditions for statics equilibrium
    - First static equilibrium condition: on the resultant force
    - Second static equilibrium condition: on the resultant moment of the force (torque)
- **Application of laws of statics equilibrium on beams with concentrated load**
  - ✓ Diving bod
  - ✓ Free body diagram
  - ✓ Reaction forces and moments
- **Application of laws of statics equilibrium on beams with distributed load**
  - ✓ Diving body
  - ✓ Free body diagram
  - ✓ Reaction forces and moments
- **Application of laws of statics on planar trusses**
  - ✓ Triangular planar truss
  - ✓ Free body diagram
  - ✓ Reaction force and moments
- **Description of Mechanical properties of materials**
  - ✓ Elasticity
  - ✓ Tensile stress
  - ✓ Compressive stress
  - ✓ Tensile strain
  - ✓ Compressive strain
  - ✓ Young's modulus
  - ✓ Volume stress
  - ✓ Volume strain
  - ✓ Bulk modulus
  - ✓ Shear stress
  - ✓ Shear strain
  - ✓ Poisson ratio

- ✓ Stress strain diagram
  - Elastic region
  - Elastic-plastic region
  - Elastic limit
  - Yield point
  - Yield strength
  - Stress-strain data analysis
- ✓ Work done in a strain

- **Application of Artificial intelligence for material properties generation**
  - ✓ Machine learning
    - Data collection
    - Model training
    - Model testing
  - ✓ Artificial intelligence materials generation

Resources required for the indicative content	
Equipment	whiteboard and chalkboard, computer, projector, textbooks
Materials	PPT, Chalks, markers
Tools	Various measuring instruments, Scientific calculator
Facilitation techniques	• Demonstration and simulation • Individual and group work • Practical exercise • Trainer guided documentation • Group discussion • Documentary research
Formative assessment methods	• Written assessment • Oral presentation • Project based assessment

Learning outcome 4: Apply mechanical vibration and Wave Optics	**Learning hours: 25**
Indicative content	

- **The applications of the mechanical vibration**
  - ✓ Periodic oscillations
  - ✓ Harmonic oscillators
    - Motion of mass attached on a spring
      - Simple pendulum
      - Motion of liquid in a U-tube
      - LC circuit (non-mechanical oscillation)
  - ✓ Damped free oscillators
  - ✓ Driven oscillators and resonance
  - ✓ Coupled oscillators
  - ✓ Beat phenomena
- **Description of the mechanical wave propagation**
  - ✓ Wave concepts
  - ✓ Types of waves
    - Longitudinal waves
    - Transversal waves
  - ✓ Wave motion
    - One dimensional wave function
    - Travelling wave
    - Speed of a wave on a string
    - Wave reflection and refraction
    - Energy transport by waves
    - Energy density of the wave
    - Power of the wave
    - Standing waves
    - Sound wave
- **Description of earthquake and seismic waves**
  - ✓ Introduction to earthquake
  - ✓ Plate tectonics
  - ✓ Causes of earthquakes
  - ✓ Formation of Seismic waves
  - ✓ Types of seismic waves
  - ✓ Seismic measurements
  - ✓ Seismology
- **The application of Huygens law, Bragg's and Snell's laws based on types of wave-matter interaction**
  - ✓ Hugen's principle
  - ✓ Bragg's law: Application in Crystallography
  - ✓ Snell's law (refraction law): Application in Optics
- **The application of the laws of Interference and polarization in line with properties of light waves**
  - ✓ Interference concepts
  - ✓ Superposition principle
  - ✓ Young's double-slit experiment
    - Path difference
    - Conditions for constructive interference

- Conditions for destructive interference

✓ Real world interreference applications
- Thin film interference: oil slicks, soap bubble
- Interference in Michelson interferometers (e.g., for measuring small distances)
- Interference in diffraction gratings (e.g., in spectrometers)

✓ Diffraction
- Single-slit diffraction
- Double-slit diffraction
- Practical applications

✓ Polarization
- Polarization concepts
- Unpolarized light
- Polarization by transmission
- Types of polarization
- Polarization by reflection
- Applications of polarization

Resources required for the indicative content	
Equipment	computer, whiteboard, chalkboard, projector, textbooks
Materials	PPT, markers, internet
Tools	Various measuring instruments, Scientific calculator
Facilitation techniques	• Demonstration and simulation • Individual and group work • Practical exercise • Trainer guided documentation • Group discussion • Documentary research
Formative assessment methods	• Written assessment • Oral presentation • Project based assessment

Learning outcome 5: Categorize Mobile phone, optical fiber and radio communication	**Learning hours: 15**
Indicative content	

- **The interpretation of concepts based on transmission system**
  - ✓ Transmission media
    - Wire pair
    - Coaxial cable
    - Fiber-optic cable
    - Radio
- **Transmission signal generation**
    - Smoke Signals
    - Carrier Pigeons
    - Semaphore Telegraph
    - Morse Code and Telegraph
    - Pony Express
    - Telephones
    - Radio
    - Television
    - Fax machines
    - Telegraphy and Telephony Networks
  - ✓ Frequency
  - ✓ Electrical signals
  - ✓ Signal Modulation
    - Amplitude Modulation (AM)
    - Frequency Modulation (FM)
    - Phase Modulation (PM)
    - Pulse Code Modulation (PCM)
  - ✓ Transmission of information
      - Analog transmission
      - Digital transmission
      - Binary digital signal
- **Description of optical fibre in telecommunication systems**
  - ✓ Types of optical fibres
  - ✓ Optical fibre transmission condition
  - ✓ Optical transmitters
  - ✓ Optical receiver
  - ✓ Lasers
- **Description of Radio communication systems**
  - ✓ Basic principles
  - ✓ Transmitter
  - ✓ Simple receiver
  - ✓ Other receivers
  - ✓ Radio Receiving system
  - ✓ Radio transmitting system
- **Description of Mobile communication systems**
  - ✓ Cellular Network Architecture
  - ✓ Components of a mobile
    - Communication System
  - ✓ Generation of Mobile Networks

- First Generation (1G)
- Second Generation (2G)
- Third Generation (3G)
- Fourth Generation (4G)
- Fifth Generation (5G)

✓ Mobile Data Services
✓ Mobile Security
✓ Roaming
✓ IOT connectivity
✓ Emerging Technologies

- **Descriptions of signal and image processing Principles**

✓ Signal Processing
- Introduction to signals
- Analog Signal Processing
- Digital Signal Processing
- Sampling and Quantization
- Signal Representation
- Filtering and convolution
- Signal Processing Tools

✓ Image Processing
- Introduction to Image Processing
- Digital Image Representation
- Image Enhancement
- Spatial Domain Processing
- Image Compression
- Image Segmentation
- Practical Projects

Resources required for the indicative content	
Equipment	whiteboard, computer, projector, textbooks
Materials	PPT, Markers
Tools	Various measuring instruments, Scientific calculator
Facilitation techniques	• Demonstration and simulation • Individual and group work • Practical exercise • Trainer guided documentation • Group discussion • Documentary research
Formative assessment methods	• Written assessment • Oral presentation • Project based assessment • Practical assessment (Labs)

Learning outcome 6: Apply fundamentals of quantum mechanics	Learning hours: 10

Indicative content

- **The description of the duality wave-particle**
  - ✓ The duality wave-particle
  - ✓ Wave-like properties
  - ✓ Particle-like properties
  - ✓ Planck's constant
  - ✓ Photoelectric effect
  - ✓ Compton effect
  - ✓ De Broglie wavelength
- **The description of measurements in quantum mechanics**
  - ✓ Observable properties
    - Position
    - Momentum
    - Spin
  - ✓ uncertainty principle
    - simplified Heisenberg's uncertainty
    - superposition principle
- **Applications of computational physics tools on the quantum mechanics problems**
  - ✓ Python modules for simulation of quantum mechanics phenomena
  - ✓ Machine learning for quantum data analysis
    - Data collection
    - Model training
    - Model testing

Resources required for the indicative content

Equipment	whiteboard, computer, projector, textbooks
Materials	PPT, markers
Tools	Various measuring instruments, Scientific calculator
Facilitation techniques	• Simulation software • Individual and group work • Practical exercise • Trainer guided documentation • Group discussion • Documentary research
Formative assessment methods	• Written assessment • Oral presentation

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