education

Department:
Education
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATES (VOCATIONAL)

SUBJECT GUIDELINES

PHYSICAL SCIENCE

NQF LEVEL 2

September 2007

INTRODUCTION

A. What is Physical Science?

Physical Science focuses on investigating physical and chemical phenomena through scientific enquiry. By applying scientific models, theories and laws, it seeks to explain and predict events in our physical environment. This subject also deals with society's desire to understand how the physical environment works, how to benefit from it and how to care for it responsibly.

B. Why is Physical Science important in this programme?

Physical science plays an increasingly important role in the lives of all South Africans due to its influence on scientific, technological and engineering development, which underpins our country's economic growth and the social well-being.

Physical Science focuses on the scientific knowledge and principles used in the vast engineering and related technology context. The engineering subjects focus on the equipment, design and related communication applications, systems and processes used. This subject cuts across all engineering fields and the chemical industry, as all fields use both chemistry and physics.

The Physical Science curriculum must ensure increased access to scientific knowledge, scientific literacy and access to higher education in the context of engineering.

C. The link between Physical Science Learning Outcomes and the Critical and Developmental Outcomes

The Physical Science Learning Outcomes were adapted from the Critical and Developmental Outcomes and the relationships are indicated as follows:

- The practical assignments and all content represent Critical Outcomes 1 to 5 by focussing on process skills, scientific reasoning, critical thinking, problem solving and working effectively with others and individually. The activities are also reflected in Developmental Outcome 1.
- All content in the Subject Outcomes represent Critical Outcomes 4 and 5 by focussing on constructing, understanding and applying scientific knowledge. The content is also reflected in Developmental Outcomes 1 and 4.
- Subject Outcome 7 specifically represents Critical Outcomes 1, 3, 4, 6 and 7 as students show the ability to see the world as a set of interrelated systems by understanding the interrelationship between science, technology, society, ethics and the environment. The Subject Outcome is also reflected in Developmental Outcomes 2 and 3.

D. Factors that contribute to achieving Physical Science Learning Outcomes

Physical Science, as a subject, should:

- Enhance understanding of chemistry and physics in such a way that the understanding of these two bodies of knowledge complements each other.
- Give students the opportunity to work in scientific manner to understand and deal with the natural and physical world in which they live and study.
- Stimulate students' curiosity, deepening their interest and allow then to reflect on the natural and physical world in which they study and live.
- Develop useful skills and attitudes that will prepare students for real-life situations.
- Develop insights and respect for different scientific perspectives and sensitivity to cultural beliefs and practices in society.
- Enhance understanding that the technological applications of the physical sciences should be used responsibly towards social, human, environmental and economic development both in South Africa and globally.

Progression in Physical Science is reflected in the differentiation of the problem-solving situations as they increasingly use less routine problem-solving skills and more higher order problem-solving skills. Increasing the problem-solving concepts need not to increase the complexity of the problem.

Progression in the content of Physical Science is reflected in the increase in quantity and depth of understanding of the applied principles of the core content to develop a well-organised knowledge base.

Progression in the increased ability to analyse and evaluate the impact of science and technology on the environment and socio-economic development is reflected where knowledge of Physical Science is applied in everyday situations and industry.

PHYSICAL SCIENCE – LEVEL 2

CONTENTS

1 DURATION AND TUITION TIME

This is a one-year instructional programme comprising 200 teaching and learning hours. The subject may be offered on a part-time basis provided the student meets all the assessment requirements.

Students with special education needs (LSEN) must be catered for in a way that eliminates barriers to learning.

2 SUBJECT LEVEL FOCUS

The student should be able to:

- Identify, describe and apply principles of scientific and technological knowledge and explain the nature of science and its relationship to technology, society and the environment.

This is done by:

- Applying process skills, scientific reasoning and strategies to investigate in a variety of scientific, technological, environmental and everyday contexts.
- Stating, interpreting and applying scientific and technological knowledge in context.
- Identifying the impact of scientific knowledge on the quality of human, environmental and socio-economic development.

  Range of scientific and technological knowledge includes mechanics, waves, electricity and magnetism, matter and materials, chemical changes and chemical systems in industry.

3 ASSESSMENT REQUIREMENTS

Physical Science equips students with a range of skills, supplemented by a broad knowledge base, a positive attitude and values that will ultimately serve the student to become an economically active, responsible and participative member of society.

Achievement in this subject will be assessed internally, with various assessment tools measuring different skills, knowledge and values and assessed externally to maintain standard.

3.1 Internal assessment (50 percent)

All internal assessments must be finalised by a qualified Physical Science lecturer or an assessor with at least a certificate of competence.

3.1.1 Theoretical component

The theoretical component forms 50 percent of the internal assessment mark.

Internal assessment of the theoretical component in Physical Science Level 2 takes the form of observation, class questions, group work, individual discussions with students, class, topic and semester tests and internal examinations. Lecturers can observe students when marking exercises from the previous day and asking class questions.

Assignments, case studies and tests can be completed at the end of a topic. Tests and internal examinations must form part of the internal assessment.

3.1.2 Practical component

The practical component forms 50 percent of the internal assessment mark.

Practical components include applications and exercises. All practical components must be indicated in a Portfolio of Evidence (PoE).

Practical investigation and performance tasks are set equally on chemistry and physics. All these tasks must be based on the theoretical component to ensure students have a comprehensive understanding, which integrates skills, values and attitudes of the content.

- **Some examples of practical assessments include, but are not limited to:**

  A. Practical demonstration

B. Visits undertaken by students based on a structured assignment task
C. Research
D. Task performance in a "Structured Environment"

- **Definition of the term "Structured Environment"**

For the purposes of assessment 'Structured Environment' refers to:

- a laboratory,
- a classroom simulated as a laboratory, or
- a class that is adapted for group work. This classroom must have a clear safety exit, space to set out apparatus and facilities where chemicals and water can be used.

- **Some of the required skills for practical assessments tasks**

The student should be able to:

- Plan and conduct a scientific investigation and collect data systematically with regard to accuracy and reliability: collect, assemble and use appropriate apparatus, make and record observations, take and record measurements in tables, etc.
- Seek patterns and trends in the information collected and link it to existing scientific knowledge to help draw conclusions: analyse data using graphs, calculations, etc., interpret results, formulate and test hypotheses, etc.
- Communicate and present collected information and conclusions with relevant scientific arguments: synthesise, evaluate and give conclusions.

Students should be able to present their scientific knowledge and conclusions in a practical report. Practical reports should have the following headings:

HEADING	DESCRIPTION
Aim or hypothesis	• State what the experiment is about and the problem that must be solved or investigated. • Reflect this aim in the result or conclusion of the practical task.
Apparatus	• Draw a labelled diagram of the experimental set up or apparatus or list reactants.
Method	• Explain how the experiment was performed in bullet or note form.
Observation	• State what was noticed using the senses, e.g. ticker tape dot spacing, bulbs brighter, colour changes, bubbles, smell and sound.
Results recorded	• Use a table to record the data (measurements or observations). • State the variable and its unit in the table's heading. (The heading must be informative.) • Do not write units with the recordings. • Repeat experiments to verify the previous results. (If readings differ, repeat the experiment again to find the correct results. All three sets of readings must be noted in the table.)
Interpretation of results	• Use a graph to interpret the data in the table. • Give the graph a title. • Use appropriate axes – the axes must be labelled and in the correct scale. • Look at the results in the table to see if there are any patterns or anything that supports or refutes the investigative question. • Use calculations to manipulate the data to show explanations. • Explain, if possible, the result.
Conclusion	• Mention if the data and interpretations answered the investigative question. • Answer the following questions in the conclusion: • Do the results or data support the hypothesis? • Can predictions be made from the results or data? If so, what predictions? • What sources of error could have influenced the result? • Should safety or hygienic measures be taken? If so, what measures?

- **Evidence in practical assessments**

All evidence pertaining to evaluation of practical work must be reflected in the students' Portfolio of Evidence (PoE). The tools and instruments constructed and used to conduct these assessments must be clear from the evidence contained in the Portfolio of Evidence (PoE).

3.1.3 Processing of internal assessment mark for the year

A year mark out of 100 is calculated by adding the marks of the theoretical component (50 percent) and the practical component (50 percent) of the internal continuous assessment (ICASS).

INTERNAL CONTINUOUS ASSESSMENT (ICASS) (to be completed through the year)	
Tasks	**Value**
• One mark consisting of 2 control tests.	10
• One exam (midyear).	20
• One mark consisting two assignments – research tasks	20
• ISAT	10
• One mark consisting of four practical tasks	40
Total	100

3.1.4 Moderation of internal assessment mark

Internal assessment is subjected to internal and external moderation procedures as set out in the *National Examinations Policy for FET College Programmes*.

3.2 External assessment (50 percent)

A National Examination is conducted annually in October or November by means of a paper(s) set and moderated externally. A practical component will also be assessed.

External assessment details and procedures are set out in the *Assessment Guidelines: Physical Science* (Level 2).

4 WEIGHTED VALUES OF TOPICS

PAPER 1	
TOPICS	**WEIGHTED VALUE**
1. Measurements and Scientific Measurements	5%
2. Mechanics	40%
3. Waves, Sound and Light	25%
4. Magnetism and Electricity	30%
PAPER 2	
TOPICS	**WEIGHTED VALUE**
5. Matter and Materials	35%
6. Chemical Change	35%
7. Chemical Systems and Industry	30%

5 CALCULATION OF FINAL MARK

Internal assessment mark:	Student's mark/100 x 50 = a mark out of 50 (a)
Examination mark:	Student's mark/100 x 50 = a mark out of 50 (b)
Final mark:	**(a) + (b) = a mark out of 100**

All marks are systematically processed and accurately recorded to be available as hard copy evidence for, amongst others, reporting, moderation and verification purposes.

6 PASS REQUIREMENTS

The student must obtain at least fifty (50) percent in ICASS and fifty (50) percent in the examination.

7 SUBJECT AND LEARNING OUTCOMES

On the completion of Physical Science Level 2, the student should have covered the following topics:

Topic 1: Measurements and Scientific Investigation.
Topic 2: Mechanics
Topic 3: Waves, Sound and Light
Topic 4: Magnetism and Electricity
Topic 5: Matter and Materials
Topic 6: Chemical Change
Topic 7: Chemical Systems and Industry

7.1 Topic 1: Measurements and Scientific Investigation

Subject Outcome 1: Identify and apply the metric system.

Learning Outcomes:

The learner should be able to:

- Identify and use SI symbols and units correctly.
- Measure length, volume (including cm^3, dm^3), volt and ampere, time, mass and weight.

Subject Outcome 2: Conduct scientific investigations and collect, represent and interpret data.

Learning Outcomes:

The learner should be able to:

- Conduct a scientific investigation and collect data systematically with regard to accuracy and reliability.
- Seek patterns and trends in the information collected and link it to existing scientific knowledge to help draw conclusions.
- Present collected information and conclusions with relevant scientific arguments.

7.2 Topic 2: Mechanics

Subject Outcome 1: Identify, describe and apply principles of motion in one dimension.

Learning Outcomes:

The learner should be able to:

- Describe motion and identify and define the components of motion.

  Range: Components of motion are position, displacement, distance, speed, velocity, average velocity, instantaneous velocity, uniform velocity and constant acceleration.
- Define and represent vector and scalar and identify examples.
- Define resultant and equilibrant and determine resultant and equilibrant by construction.

  Range: Resultant of multiple vectors not acting on one point and two vectors acting one point
- Apply the concept of relative motion.
- Do calculations on components of motion.
- Solve problems using linear equations of motion (horizontal).

  Range: Linear equations of motion are $v_f = v_i + a\,\Delta t$, $s = v_i\,\Delta t + \frac{1}{2}\,a\Delta t^2$, $v_f^2 = v_i^2 + 2as$

Subject Outcome 2: Identify and apply principles of force.

Learning Outcomes:

The learner should be able to:

- Define force, describe different types of force and identify examples.

  Range: Types of force can be gravitational, mechanical, elastic, frictional, etc.

- Identify and draw diagrams indicating action-reaction forces.

  Range: Action-reaction forces indicate forces in contact: frictional force, applied force, normal and gravitational force (on horizontal and incline plane)

  Forces not in contact: opposite poles of magnets, opposite charges and Newton's Law of Universal Gravitation
- Define gravitational acceleration: g.
- Describe and calculate weight.
- Differentiate between mass (m) and weight (or $F_{gravitation}$).

Subject Outcome 3: Identify, describe and apply principles of mechanical energy.

Learning Outcomes:

The learner should be able to:
- Define mechanical energy, kinetic energy and gravitational potential energy.
- Calculate kinetic energy ($E_K = ½mv^2$) and gravitational potential energy ($E_p=mgh$).
- Define the law of conservation of mechanical energy.
- Solve problems using the conservation of mechanical energy ($E_{mechanical}= E_K +E_p$).

Subject Outcome 4: Identify, describe and apply principles of simple machines and mechanical advantage in everyday contexts.

Learning Outcomes:

The learner should be able to:
- Describe and identify the functions of simple machines.

  Range: Functions are transfer energy, multiply force in expense of velocity, multiply speed in expense of force and change direction of force.
- State and identify examples of the six basic machines: lever, wheel and axle, pulley, inclined plane, screw and wedge.
- State and use the law of simple machines in calculations.
- Define mechanical advantage as:
  - Ideal mechanical advantage (IMA) = distance effort F moves ÷ effort resistance F moves
  - Actual mechanical advantage (AMA) = resistance force ÷ effort force
- Calculate % efficiency of machine: % Efficiency = AMA ÷ IMA x100.
- Draw diagram and calculate mechanical advantage of levers.

  Range: Levers considered are a) the fulcrum between the resistance force and effort force, b) the resistance force between the fulcrum and effort force and c) the effort force between the fulcrum and the resistance force.

7.3 Topic 3: Waves, Sound and Light

Subject Outcome 1: Identify, describe and apply principles of waves.

Learning Outcomes:

The learner should be able to:
- Identify and describe vibration and oscillation as a periodic motion.
- Define period, frequency and amplitude.
- Define a wave and identify different examples.
- Describe the nature of waves as a disturbance that travels and not the medium and it carries or transfers energy.
- Distinguish between the two categories of waves, longitudinal and transversal, and identify examples.
- Identify particle position on graphs showing displacement to illustrate difference between longitudinal and transversal waves.
- Draw, label and interpret a displacement position graph of a simple harmonic wave showing wavelength and amplitude.
- Calculate frequency, period and wave speed and wavelength of a transversal wave.
- Describe the effect of medium on wave speed.
- Distinguish between standing and moving waves and identify and describe superposition in standing waves.

Subject Outcome 2: Identify, describe and apply principles of geometrical optics in everyday contexts.

Learning Outcomes:

The learner should be able to:

- Identify light as a transversal wave.
- Identify and describe the wave properties of light: reflection and refraction.
- Draw diagrams showing reflection, angle of incidence and angle of reflection using plane, concave and convex of mirrors and the type, size and distance of image formed.
- Draw and interpret diagrams showing refraction (angle of the light ray in the two media and normal).

  Range: Media can be air, glass, Perspex, water and oil.
- Draw and interpret diagrams showing total internal reflection with reference to fibre optics, endoscopes and telecommunications.

7.4 Topic 4: Magnetism and Electricity

Subject Outcome 1: Identify, describe and apply principles of magnetism.

Learning Outcomes:

The learner should be able to:

- Draw and label diagrams showing magnetic field of permanent magnets.
- Describe the effect that poles of permanent magnets have on each other.
- Identify and describe the earth's magnetic field and declination and the working of a compass.
- Apply magnetic phenomena by induction of the earth's magnetic field and refer to iron and steel used in building construction.
- Describe magnetic shielding and its purpose.

Subject Outcome 2: Identify, describe and apply principles of electrostatics (static electricity).

Learning Outcomes:

The learner should be able to:

- Identify two kinds of charges and describe how an object becomes charged.
- Define law of conservation of charge.
- Identify and predict the distribution of charge over the surface of a conductor (spherical and non-spherical).
- Identify and predict action between electric charges, the attraction between charged and uncharged objects and action of highly charged points.
- Identify and describe electrostatic induction.
- Apply the principle of discharge to a charged rod using ions in a flame and ions in the atmosphere and atmospheric electricity and the use of a lightning conductor.

Subject Outcome 3: Identify, describe and apply properties of electricity in an electrical circuit.

Learning Outcomes:

The learner should be able to:

- Define and calculate electrical current.
- Differentiate between the two types of current (AC and DC).
- Describe and identify resistance in terms of length, cross-sectional area and type of material.
- Determine and describe the relationship between load (total resistance) and current.
- Define electrical potential difference (voltage) and emf and give examples of sources.
- Determine potential change when cells are grouped and potential division in a series circuit.
- Describe the reason for electrical safety and earthing.

7.5 Topic 5: Matter and Materials

Subject Outcome 1: Identify, describe and classify matter according to different macroscopic properties.

Learning Outcomes:

The learner should be able to:

- Identify and describe the phases of matter (physical property of matter).
- Distinguish between the phases of matter in terms of energy, shape and volume.

- Classify and describe materials using observation and research according to macroscopic properties.

  Range: Macroscopic properties referred to are metals, semi-metals and non-metals; magnetic and non-magnetic materials; electrical conductors, semi-conductors and isolators; thermal conductors and isolators; relative density; acids, bases (and related pH).

Subject Outcome 2: Identify and describe atoms as the basic building block.

Learning Outcomes:

The learner should be able to:

- Identify and sketch the orbit structure of the atom showing the position (nucleus and orbit) of the protons, neutrons and electrons in shells.
- Differentiate between atomic number and atomic mass.
- Define and identify an isotope and refer to common examples that are used.

Subject Outcome 3: Identify, describe and apply properties of the periodic table.

Learning Outcomes:

The learner should be able to:

- Recognise the arrangement of atoms in the periodic table according to atomic number.
- Identify and describe group, period and periodicity.
- Arrange electrons into core and valence electrons and write electron configuration of first 20 elements down.
- State the names of groups (1, 2, 7, 0) and identify the transition metal group.
- Describe and interpret the meaning of groups (similar chemical activity or activity trends.)
- Recognise the distribution of metals and non-metals.

Subject Outcome 4: Identify and describe particles.

Learning Outcomes:

The learner should be able to:

- Identify and define atoms, ions and molecules (simple and giant).
- Identify, define and give examples (in all three phases) of pure substances: elements and compounds.
- Identify, define and give examples (using all three phases) of mixtures: heterogeneous and homogeneous (refer also to alloys).
- Identify and describe intermolecular bonding referring to covalent, ionic and metallic bonding.
- Explain macroscopic properties in terms of chemical bonding (microscopic properties).
- Name and write chemical formulae of generally used substances.

7.6 Topic 6: Chemical Change

Subject Outcome 1: Identify, describe and apply principles of heat.

Learning Outcomes:

The learner should be able to:

- State the First Law of Thermodynamics: principle of conservation of energy.
- Define temperature and measure temperature using thermometers (Kelvin and Celsius scales) and colours of heated objects.
- Describe heat and heat transfer (see thermal conductors).
- Define and calculate heat capacity and specific heat.

Subject Outcome 2: Differentiate between physical and chemical change.

Learning Outcomes:

The learner should be able to:

- Identify and distinguish between physical and chemical changes and give examples.
- Identify and apply physical and chemical methods of separating mixtures (solids, liquids and gases).

  Range: Separation methods are manual, magnetic, filtration, fractional distillation, using a separating funnel, precipitation reactions and chromatography.

Subject Outcome 3: Identify, describe and apply principles of chemical reactions (electrolytes).

Learning Outcomes:

The learner should be able to:

- Identify and describe electrolytes.
- Describe hydrolysed salts as sources of electrolytes and determine the solubility of salts as measured by conductivity of solution.
- Identify acids as potential sources of electrolyte.
- Identify the interaction (displacement reactions) and effect of ions in aqueous solutions (e.g. corrosive).

Subject Outcome 4: Determine the quantitative aspects of change.

Learning Outcomes:

The learner should be able to:

- Calculate atomic, molecular and formula mass.
- Calculate amount of substance in mole and gram.
- Calculate concentration of solutions.

7.7 Topic 7: Chemical Systems and Industry

Subject Outcome 1: Identify and describe the impact of scientific knowledge of the hydrosphere on the quality of human, environmental and socio-economic development.

Learning Outcomes:

The learner should be able to:

- Describe the water cycle, its physical changes and energy transfers.
- Identify and describe the macroscopic properties of the three phases of water related to their microscopic structure.
- Define the term water pollution and give examples (also refer to industrial, agricultural and human pollution).
- Classify water in terms of hardness and explain water hardness and describe its effects.
- Describe the types of impurity found in water and the reason for purification (human and industrial).
- Define water treatment and softening and give examples.

8 RESOURCE NEEDS FOR THE TEACHING OF PHYSICAL SCIENCE – LEVEL 2

8.1 Physical resources

The subject requires a venue that can accommodate demonstrations and practical tasks in Physics and Chemistry.

Lecturers and students must take care when handling chemicals, electricity and any equipment.

The number of students per practical depends on the human resources available, the venue size and applicable regulations.

8.2 Human resources

The lecturer should be proficient in Physics and Chemistry. The lecturer must be familiar with the engineering and industrial contexts applicable to Physical Science as well as outcomes-based teaching and learning and assessment principles.

A laboratory assistant may be useful, if justified by the number of students and classes at the college.

8.3 Other resources

Learning and training material needed are the following:

- General teaching material for the lecturer
- Textbooks or guidelines per student
- Portfolio file (paper) per student
- Equipment
- Wall charts, for example, the periodic table or anything the lecturer regards as applicable to and illustrative of the content
- Board ruler and compass

APPARATUS Needed for demonstrations and practical tasks performed by students	
• Calliper, ruler and protractor • Air track and accessories • Air blower • Track, trolleys (2), pulley, ticker timer, carbon disks and tape • Stop watch • Power supply • Slinky spring • Light kit • Microwave basic kit • Oscilloscope • Magnets, iron filings and small compasses • Circuit board (Worcester and accessories) and batteries • Resistors, rheostat sliding and globes • Voltmeter and ammeter • Leads and croc-croc clips • Joule meter or mains input or watt measurer • Thermometer • Tripod and asbestos sheet • Backpacking gas an burner • Bunsen burner, if used with bottle gas • Retort stand, clamps and boss head • Crucible tongs • Test tube brushes • Safety goggles • Filter paper • Paper towel and dispenser	• Disposable plastic syringes • Rubber tubing • Rubber stoppers for flasks and test tubes • Cork borer • Wash bottle • Spatula • Apparatus trolley • Conductivity apparatus used for liquids • pH meter or indicator test paper • Balance for measuring mass • Digital balance • Material test apparatus, samples and software • Polystyrene spheres and/or atom molecular set • Crystal model set • Beaker squat (50cc, 100cc , 250cc and 1000cc) • Erlenmeyer flask (250cc) • Volumetric flask (50cc,100cc, 250cc and 1000cc) • Erlenmeyer and sidearm • Funnel • Watch glass • Measuring cylinders (25 ml, 50ml and 250ml) • Water trough • Crucible with lid • Mortar and pestle • Medicine droppers • Bottle dropper • Reagent bottles • Separating funnel

CHEMICALS	
• acetic acid • ammonia sol 25% • ammonium nitrate • ammonium chloride • barium chloride • carbon • calcium hydroxide • calcium carbonate marble • calcium powder • calcium metal • cobalt chloride • copper sulphate • copper metal turnings • hydrochloric acid 32% • iodine crystal • iron sulphide • steel wool • iron(iii)chloride • lead nitrate	• lead metal • magnesium ribbon • magnesium sulphate (Epson salts) • potassium bromide or sodium bromide • potassium chloride or sodium chloride • potassium iodide or sodium iodide • potassium metal • potassium hydroxide • potassium permanganate • silver nitrate solution • sodium carbonate • sodium bicarbonate • sodium dichromate • sodium metal • sodium thiosulphate • sulphur powder • sulphuric acid • zinc granular • zinc carbonate