2023 NCEA Assessment Report

Subject:	Physics
Level:	Level 3
Achievement standard(s):	91523, 91524, 91526

General commentary

The examination was a paper based written examination covering wave systems, mechanical systems, and electrical systems.

Each paper consisted of three questions with four parts. Candidates were expected to respond to all questions

Report on individual achievement standard(s)

Achievement standard 91523: Demonstrate understanding of wave systems

Assessment

A paper based one hour examination covering standing waves, Doppler effect, beats, and interference patterns.

Commentary

Question One was completed to a higher quality/level of understanding, presumably as this question was the most similar to questions from previous years.

Many students confused crests with antinodes and applied antinodes incorrectly to beats and interference patterns.

Many students also incorrectly attributed path difference to the formation of beats

Diffraction was poorly understood and used interchangeably with interference.

Grade awarding

Candidates who were awarded **Achievement** commonly:

- carried out simple calculations
- drew a simple wave on a string diagram
- used the frequency given to identify the third harmonic
- used the Doppler equation correctly
- recognised that a source moving toward an observer, results in a higher observed frequency
- calculated beat frequencies correctly
- recognised that in a spectrum, red light is furthest from the central maxima
- described beats or diffraction incorrectly
- confused frequency with volume in the Doppler effect

- confused crests with antinodes (in trying to describe beats) or crests with antinodes (in describing interference patterns)
- confused path difference as the reason for the formation of beats.

Candidates who were awarded **Achievement with Merit** commonly:

- rearranged formula successfully
- calculate the speed of waves on a string
- demonstrated understanding between the length of a string and the wavelength
- described fully the Doppler effect and explained it using $v = f\lambda$
- described and explained the formation of beats
- recognised that the path difference leads to a phase difference, and hence a resulting interference pattern
- used the formula to explain the relationship between path difference and the angle to the maxima.

Candidates who were awarded **Achievement with Excellence** commonly:

- identified and used physics formula to support their answer
- provided clear answers, linking several concepts, in a clear and coherent manner
- understood how relative velocity resulted in the observed Doppler effect
- explained the phenomena of resonance
- recognised that the small angle approximation is not valid for larger angles
- recognised the effect of multiple sources being key to the observed pattern from a diffraction grating.

Candidates who were awarded **Not Achieved** commonly:

- did not follow the scaffolded bullet points
- did not use the correct vocabulary
- did not use the relevant formulae to guide or support answers
- could not determine the relationship between string length and wavelength
- could not identify harmonics
- drew waves on a string incorrectly
- could not describe beats or diffraction
- confused crests with antinodes (in trying to describe beats) or crests with antinodes (in describing interference patterns)
- gave the order of the spectra in an interference pattern, the wrong way round.

Achievement standard 91524: Demonstrate understanding of mechanical systems

Assessment

The examination consisted of three questions that covered circular motion, rotational motion, and simple harmonic motion. Each question had four parts with two opportunities for excellence in each question.

Commentary

Being able to draw correct vectors enabled candidates to demonstrate their understanding of forces involved in circular motion. Vectors require a correct direction, size and label.

A firm grasp on physics terminology, for example, the application of conservation of energy to rotational and linear kinetic energy, enabled the candidates to demonstrate an in-depth understanding of the principle of conservation of energy. Candidates should guard against defaulting to Level 1 energy conservations for more complex L3 scenarios, i.e. on a vertical loop or with a rolling object down an incline.

Candidates with frequent experience with or awareness of the practical examples were able to visualise everyday examples. For example, picturing the cart as supporting the motion, instead of hanging from the track somehow.

Some candidates demonstrated their knowledge of the symbols and quantities in some relationships, e.g. $v = r\omega$ and $L = mvr$. and how these can correctly be applied to rotational motion contexts. Candidates who were able to solve for θ inside a trigonometric function were more successful in calculations.

Grade awarding

Candidates who were awarded **Achievement** commonly:

- drew F_c / F_{net} parallel to the banked slope instead to horizontally
- calculated weight and centripetal force correctly, but had errors in either their rearrangement to find θ or calculated the incorrect angle
- identified weight force on a vertical loop roller coaster but confused the sizes and / or name and/or direction of the reaction force
- calculated the minimum velocity at the top of a loop, but did not recognise the need to include this in the energy transformation calculation i.e defaulted to E_p(top) = E_k(bottom)
- provided incomplete energy transformations e.g did not recognise both E_k(lin) and E_k(rot)
- calculated the rotational velocity of an object
- identified rotational inertia and related this to the conservation of angular momentum
- calculated the angular acceleration of an object using rotational kinematics
- calculated a gradient but were often unable to link this to the formula provided to calculate the time period
- selected a correct SHM equation, but often substituted incorrect values or rearranged incorrectly or calculated an angle incorrectly
- identified damping
- confused the meanings of L3 symbols and equations, and hence applied them incorrectly
- performed the single first step in a multi-step calculation.

Candidates who were awarded **Achievement with Merit** commonly:

- identified F_c / F_{net} and drew a correct vector diagram
- calculated the banking angle for horizontal circular motion
- made partially correct explanations about heaviness / weightlessness on a roller coaster, but these were incomplete or contained errors
- identified the conditions for weightlessness and calculated the minimum speed, but were unable to use this in conjunction with identifying the correct energy transformations and often assumed E_p(top) = E_k(bottom)
- provided incomplete energy transformations, e.g. did not recognise both E_k(lin) and E_k(rot)
- completed two out of three steps of a multi-step calculation
- identified the relationship between inertia and angular velocity and linked to $L = I\omega$, referencing conservation of angular momentum and justifying a change in I with link to mass distribution or radius about the rotational axis
- calculated the gradient of a graph and made appropriate links in context to calculate required values
- selected SHM equations, and made attempts at solving however these included errors.
- identified damping and provided an explanation with attempts to sketch a graph.

Candidates who were awarded **Achievement with Excellence** commonly:

- completed multi-step calculations having applied the key physics principles of conservation of mechanical energy

- demonstrated in depth knowledge of key physics definitions and concepts and applied these appropriately to the problems set
- demonstrated a complete understanding of net force and recognised the difference between support, lift and tension forces
- drew vector diagrams accurately and used the reference circle to determine the time taken to travel for an object in motion under SHM
- carefully read the questions to ensure they understood what was being asked and answered every part of the question in full
- were able to make clear connections between different parts of a question.

Candidates who were awarded **Not Achieved** commonly:

- drew incorrect vectors (F_c parallel to banked surface) or vector diagrams and often used incorrect force names.
- did not calculate the angle of a banked horizontal circular track
- attempted to explain heaviness and weightlessness in terms of energy or in terms of significant misconceptions about force sizes and directions
- provided incomplete energy transformations, by not considering both E_k(lin) and E_k(rot
- did not recall key concepts or definitions related to rotational motion
- did not calculate the gradient of a graph or rearrange time period equations
- did not attempt to identify variables for SHM calculations
- did not sketch an SHM graph or identify damping
- confused the meanings of L3 symbols and equations, and so applied them incorrectly
- used incorrect or vague terminology / language
- made frequent calculation errors.

Achievement standard 91526: Demonstrate understanding of electrical Systems

Assessment

The examination consisted of three questions that covered Capacitors in DC circuits, transformers, inductors in DC circuits, and AC circuits.

Commentary

A significant number of candidates incorrectly mentioned induced current and opposing current, rather than the induced voltage and its subsequent effects.

Grade awarding

Candidates who were awarded **Achievement** commonly:

- calculated the charge and energy stored in a capacitor, and its reactance
- calculated the resonant frequency
- used the correct formula to calculate the distance between the plates of a capacitor
- calculated the time constant for a RC circuit and the voltage across one of the coils of a transformer
- described that a changing current and changing magnetic flux induced a voltage in the secondary coil of a transformer
- described the back emf for an inductor
- described the effect of increasing frequency on capacitor reactance and on the brightness of a lamp in an LCR circuit
- described the effect of frequency on the reactance of an inductor.

Candidates who were awarded **Achievement with Merit** commonly:

- solved straight-forward calculations
- made links between concepts, both mathematically and using explanations
- calculated the energy stored in a capacitor
- calculated the amount of charge stored after one time constant, and knew the shape of an exponential growth curve
- compared the energy between two different supply voltages, using calculations
- understood that a greater number of charges released per second resulted in greater current
- explained that a larger voltage and current gave a larger power
- demonstrated knowledge that a changing current, and hence a changing magnetic flux induced a voltage in a secondary coil
- recalled the purpose of a laminated soft iron core in a transformer
- demonstrated an understanding that an inductor in a DC circuit created a back emf, resulting in the delayed brightness of a lamp in the circuit
- calculated current and power in a transmission line
- calculated reactance and impedance in a RC circuit
- demonstrated an understanding between increasing frequency, reactance of a capacitor, circuit impedance, current, and the brightness of a lamp in a circuit
- demonstrated an understanding of how adding an inductor into an RC circuit at resonance would affect the brightness of a lamp in the circuit.

Candidates who were awarded **Achievement with Excellence** commonly:

- used information to calculate the time constant and plot an exponential growth curve showing charge vs time for an RC circuit
- explained why and how the brightness of the flash was affected when a 200 V supply was used instead of 1.5 V supply
- explained why an AC voltage was induced in the secondary coil of a transformer and how the presence of a laminated soft iron core affected the efficiency of the system
- used calculations to explain why voltage was stepped up in transmission lines
- explained in-depth how increasing the frequency of the supply voltage affected the brightness of the lamp in terms of reactance, impedance, current and power
- explained how and why the addition of an inductor affects the brightness of a lamp in a circuit, and the effect of resonance on a LCR circuit.

Candidates who were awarded **Not Achieved** commonly:

- did not calculate the charge stored in a capacitor
- did not demonstrate knowledge of how to calculate time constant for a RC circuit
- could not calculate the distance between capacitor plates.
- did not demonstrate knowledge of how the source voltage affected the brightness of a flash
- did not demonstrate knowledge of how transformers work and the reason for using a soft iron core
- did not demonstrate knowledge of the back emf in inductors in a DC circuit
- did not calculate the current in a transmission line
- did not calculate the reactance of a capacitor
- did not demonstrate knowledge of the effect of increasing the frequency in a CR circuit
- did not calculate resonant frequency
- did not demonstrate knowledge of about resonance in an LCR circuit.
