Villani's Square

Round 1: Numeral Nexus
Delegation cap(2 delegates)

Overview & Significance

Numeral Nexus is the opening duel round of the BNA Mathematics Module, designed as an intense, fast-paced, two-hour mathematical confrontation. This round sets the tone for the entire module by immediately immersing delegates in a high-pressure problem-solving environment where logic, speed, accuracy, and endurance are tested simultaneously.

Unlike conventional written examinations, Numeral Nexus adopts a continuous duel format, transforming mathematics into a competitive arena. Delegates must remain mentally alert throughout the round, managing their time effectively and maintaining consistency under sustained pressure.

Step-by-Step Round Progression

Numeral Nexus is a continuous duel spanning two hours. You must manage your time effectively and build a strategy to handle a volume of at least 30 questions.

Phase 1: Orientation & Setup

In these first 10 minutes, you will receive your Question Boxes. You must use this time to organize any rough-work sheets, understand the scoring rules, and mentally prepare your strategy before the duel begins.

Phase 2: Attempting the questions

In front of you, there will be two Question boxes, each containing Question Cards with different difficulty levels. As the timer starts, you must choose a card from either box. One box will contain hard difficulty questions and the other will

contain medium difficulty questions.

Evaluation Focus

Judges will rank purely on total points received, as questions carry different weightage. The evaluation focuses on:

- **Mathematical accuracy** without the safety net of partial credit.
- **Fundamental strength** across Number, Algebra, Geometry, and Functions.
- **Strategic time allocation** and problem selection.
- **Consistency and resilience** under the two-hour "duel" format.

At the conclusion of this round, **50% of the delegates will be eliminated** based strictly on these rankings. Only the top-performing delegates move forward to Round 2.

Logistics & Resources

- **Provided Resources:** Delegates will be provided with two question boxes containing cards, extra sheets for rough work, and a pen
- **Delegate Requirements:** Delegates must bring their own Calculators and personnel Stationary

Preparation & Study Guidance (Round 1)

Category	Topics & Skills to Master
Topics to Study	Number, Algebra and Graphs, Coordinate Geometry, Trigonometry, Quadratics, Functions, Polynomials, Logarithmic and Exponential Functions, and Binomial Expansion.
Skills to Master	• High-speed calculation accuracy • Quick application of core formulas • Time management under pressure • Logical and critical thinking.
Study Resources	Logarithms and Exponential equations Binomial expansion

Round 2: Quant Quest
Delegation cap(2 delegates)

Overview & Significance

Round 2, titled **"Quant Quest,"** represents the "Applied Mathematics" core of the module. This round is significant because it challenges delegates to move beyond abstract numbers and apply mathematical laws to physical systems, network optimization, and data interpretation. It tests the ability to bridge the gap between theoretical formulas and practical implementation, a skill essential for engineering, logistics, and data science.

Round Progression

Quant Quest is divided into three distinct technical segments, each requiring a different mode of mathematical thinking. Delegates must manage their time carefully and adapt their approach as the nature of the problems changes.

Part 1: Mechanics (The Physics of Math):

In this first segment, delegates face problems involving motion, forces, and energy. You will be required to calculate trajectories, resolve vectors, and solve kinematic equations. Whether determining the landing velocity of a spacecraft or the tension in a pulley system, your focus must be on technical precision and the correct application of Newtonian laws.

- Resolve vectors

- Apply kinematic equations

- Use Newton's laws to analyze motion, forces, and energy

Part 2: Path finding (The Art of Optimization):

Next, the round transitions into optimization and graph theory. Here, delegates will be tasked with finding the most efficient route through a grid or network. This involves calculating "Shortest Path" algorithms or determining the number of possible routes between two points given specific constraints. You must think strategically to find shortcuts and avoid "dead ends" in the logic.

- Finding the most efficient path through a grid or network

- Counting the number of valid routes under specific movement constraints

- Eliminating inefficient or invalid paths logically

Part 3: Statistics (The Language of Data):

In the final and most conceptually demanding section, delegates apply advanced probability and statistics to a high-stakes survival scenario involving a Mars research colony.

You will be required to model situations where:

- Resource scarcity

- Environmental variability

- System degradation and fatigue

- Interact to create compounding risks.

You must analyze how failure in one system (such as solar grids) shifts operational load to backup systems (batteries or generators), thereby altering their failure probabilities over time. This requires moving beyond descriptive statistics into predictive modelling.

Key mathematical tools include:

- Natural logarithmic regression to determine decay constants

- Predicting the exact time at which a system is likely to fail

- Tracking "consecutive use" penalties, where prolonged operation increases failure risk

- Hypothesis testing and confidence intervals to distinguish genuine safety breaches from statistical noise

Delegates must determine whether continued operation is mathematically safe or whether failure before a critical deadline is inevitable.

As variables accumulate (fuel limits, weather cycles, hardware fatigue, probability thresholds), margins for error disappear. You must justify

conclusions clearly, often using Bayes' Theorem, error analysis, or confidence bounds to defend decisions under uncertainty.

Evaluation Focus (General Criteria)

- Judges assess delegates holistically across all three sections, focusing on:

- Mathematical accuracy as complexity increases

- Correct application of appropriate models and methods

- Logical justification of decisions, not just numerical results

- Ability to interpret mathematical outcomes in real-world terms

- Clear communication of technical risk and uncertainty

Delegates who demonstrate mathematical intuition, composure, and disciplined reasoning under pressure perform best.

Logistics & Required Tools

- **Provided Resources:** Printed Question Booklets containing the three-part scenario and Answer Booklets for providing proofs and solutions.

- **Delegate Requirements:** Personal stationery (pens/pencils) and a scientific calculator are required.

Elimination

After the conclusion of Round 2, **approximately only 10 delegations will move on to the final round.**

Preparation & Study Guidance (Round 2)

Category	Possible Resources
Topics to Study:	- Kinematics and equations of motion - Vector resolution and Newtonian dynamics - Coordinate geometry and grid-based pathfinding - Combinatorics and constrained route counting - Discrete and continuous probability distributions - Expected value, variance, and standard deviation - Markov chains and state-transition models - Natural logarithmic regression and decay analysis - Bayes' Theorem and conditional probability
Skills to Master:	• Translating scenarios into mathematical models • Risk assessment and probabilistic decision-making • Clear justification of high-stakes conclusions
Study Resources:	*Continuous Probability Distributions* *Baye's Theorum* *Natural Logarithms and Logistic Regression* *Khan Academy Mechanics* *Conceptual Physics (Hewitt) for intuition* *MIT OpenCourseWare (Introductory Mechanics)* *GCSE / O-Level / IGCSE Mechanics textbooks* *AP Physics 1 (Mechanics) introductory chapters*

ROUND 3 - VILLANI SQUARE: CODE CRYPTO
Delegation cap(2 delegates)

Overview & Significance

Round 3 is the final and most decisive round of the Mathematics Module. Titled **"Code Crypto,"** this round is designed to distinguish strong problem-solvers from truly exceptional thinkers who can operate under pressure, manage uncertainty, and reason with clarity.

This round evaluates two complementary dimensions of mathematical ability. **Part 1** assesses a delegate's depth of understanding and mastery of mathematics, emphasizing structured reasoning, accurate application of concepts, and clarity of thought.
Part 2 focuses on rapid logical thinking and pattern recognition, testing how effectively delegates can analyze unfamiliar problems and respond under time pressure through brain-teaser–style challenges.

Round Progression

Part 1: Projected Question Session with Twist Bowl

As Round 3 begins, delegates will be briefed on the rules, time limits, and negative marking policy. All questions in this part are **projected on the screen**, and responses are written on the provided answer sheets.

1. Question Flow

   ● Questions are displayed **one at a time** on the projector.

   ● Questions progressively increase in difficulty, so early accuracy and confidence are important.

   2. Twist Bowl Mechanism

After **every 2–3 questions**, teams are invited to draw a chit from the **Twist Bowl**, introducing an element of strategy and unpredictability.

Possible chits include:

- **Redemption Pass** – Attempt a bonus question to recover lost points.

- **Safe Zone** – Answer the next question without negative marking.

- **High Risk (Risk Multiplier)** – Double points for a correct answer, but double penalty for an incorrect one.

- **Chain Boost** – Earn bonus points for consecutive correct answers.

- **Blank –** No perks for this chit

Part 2: Brain Teaser + Crypto Rapid Response Phase

In the second part, the round shifts into a high-intensity rapid- response format combining brain teasers and cryptography.

1. Brain Teaser Race

- Brain teaser questions are projected on the screen.

- The **first team to raise their delegate card or hand** earns the right to answer.

- If the answer is correct, the team gains points **and receives a cryptographic hint or key**.

- If incorrect, the chance passes to another team, and negative marking may apply.

The brain teasers focus on:

- Number theory

- General mathematics

- Logical deduction

- Fast pattern recognition

2. Crypto Unlock Mechanism

- Each correct brain teaser answer unlocks **one hint or key** for the encrypted message.

- A team that answers **four brain teaser questions correctly** will possess **all hints required to fully decrypt the cipher**.

- However, **unlocking all hints does not guarantee overall victory**, as:

    - Scores from Part 1 are included.

    - Negative marking can significantly affect final standings.

    - Other teams may score highly through accuracy and consistency.

Evaluation Focus (General Criteria)

Judges assess delegates holistically across both parts of the round, focusing on:

- Logical accuracy and mathematical correctness

- Speed and decisiveness under time pressure

- Clear justification of reasoning and decoding steps

- Strategic risk management, especially under negative marking

- Composure and teamwork in competitive, fast-paced conditions

Delegates who balance **accuracy, speed, and strategy** perform best.

1. **Provided Resources**

- Projector and screen
- Printed answer sheets
- Delegate cards
- Twist Bowl with chits
- Stationery (pens, markers)
- Timers / stopwatches
- Printed Crypto Code with Caesar Cipher

2. **Delegate Requirements**

- No laptops or electronic devices allowed
- Strong mental math and reasoning skills
- Familiarity with Caesar cipher

Preparation & Study Guidance (Round 3)

Category	Possible Resources
Topics to Study:	- Number theory - Modular arithmetic - Combinatorics - Classical ciphers (Caesar cipher and variants) - General mathematical reasoning - Calculus - Mechanics and Statistics - Algebra
Skills to Master:	• Deep conceptual understanding of mathematics • Logical structuring of solutions • Fast analytical thinking under pressure • Pattern recognition in unfamiliar problems.
Study Resources:	***Links:*** ***Number theory*** ***Integration Zainematics*** ***Caesar Cipher***