Quantum Quandary Division C
Washington State 2025-2026 Rules

1. **DESCRIPTION:** Teams will answer questions related to quantum physics, history of its development, applications in **materials science, instrumentation, and quantum computing.**

<u>A TEAM OF UP TO</u>: 2 **<u>APPROXIMATE TIME</u>:** 50 minutes

2. **EVENT PARAMETERS:**
   a. Each team may bring **one three-ring binder containing information in any form and from any source.** The three-ring binder may be of any size and the information contained should be attached using the available rings. The information or pages may be removed during the event. Sheet protectors and laminated sheets are allowed.
   b. Each team may bring two stand-alone calculators of any type as allowed in the national rule manual.
   c. **A sheet of relevant constants, if math is required, may be given as part of the exam.**

3. **THE COMPETITION:**
   The written test covers the following topics equally in each of the four topics (a.i-ii, b.i-ii). It can be in any form including interpretation of data, charts, circuit diagrams or graphs, or simple calculations.
   Questions on the test will use the following mathematical content:
   1. **Algebraic manipulations of multiple steps**
   2. **Basic trigonometry and vectors**
   3. ***Basic level of linear algebra, complex numbers, and statistics distribution concepts***
   4. **No questions may require the use of calculus.**

   a. Quantum Physics
      i. Basic concepts and history
         (1) Wave and particles: e.g. wavefunctions, the Born rule, superposition
         (2) Probability and uncertainty principle
         (3) Foundational experiments (e.g. double-slit) and paradoxes (e.g. Einstein–Podolsky–Rosen)
         (4) Operators, observables, quantum states
      ii. Atomic and Statistical Physics
         (1) Bohr model of atom; photoelectric effect, Compton effect
         (2) Basics of wave mechanics **and its application in quantum effects, e.g. quantum tunneling**
         (3) **Photonic physics (e.g. spectrum, lasers, light-matter interaction)**
         (4) Basics of the law of thermodynamics, entropy
   b. Applications
      i. Solid-state Materials and Quantum Instrumentation
         (1) Basics of insulators, semiconductor, superconductors
         (2) **Nuclear magnetic resonance**
         (3) **Sensitivity and noise in Quantum sensors**
      ii. Quantum Information Processing
         (1) Fundamentals of Qubits**, difference between quantum and classical computing**
         (2) Bell state and **Quantum gates, e.g. CNOT, CCNOT, H gates**
         (3) **Basics of Deutsch's and Grover's algorithms (e.g. 5.V.c) *(State-level)***
         (4) Physical realization of Quantum computers, **e.g. NV-diamond (5.V.g) *(State-level)***

4. **<u>SCORING</u>**:
   a. All questions will have been assigned a predetermined number of points.
   b. The highest score wins.
   c. Selected questions will be used to break ties.

5. <u>Recommended Resources:</u>

I. Wikipedia - good starting point for both theoretical and applications.
II. Hyperphysics (http://hyperphysics.phy-astr.gsu.edu/hbase/index.html)
III. Textbooks/Lecture Notes
- a. *Physics (any edition)*, Resnick, Halliday, Krane, John Wiley & Sons.
- b. Quantum Physics, A Beginner's Guide, Alastair Rae (2008)
- c. *The Feynman Lectures on Physics* (https://www.feynmanlectures.caltech.edu/)
- d. *Lectures notes by David Tong* (sections on quantum, solid state, and statistical physics) (http://www.damtp.cam.ac.uk/user/tong/teaching.html)
- e. *Quantum Computation and Quantum Information*, Michael Nielsen & Isaac Chuang (2010)

IV. MIT OpenCourseWare (https://ocw.mit.edu/) on Statistical Physics, Quantum Physics
V. Online introduction and videos
- a. Quantum Technology for high schooler: https://chicagoquantum.org/education-and-training/quick-quantum
- b. Quantum Computing intro: https://youtu.be/-5fKVn1GR9Y?si=bNpbeoGTPA4q_my_
- c. Quantum Computing course: https://learning.quantum.ibm.com/
  https://youtu.be/42OiBzfdE2o?si=g23g3QWAF_F6GKi8
  https://quantum.cloud.ibm.com/learning/courses/fundamentals-of-quantum-algorithms
- d. Quantum Computing for CS student: https://youtu.be/F_Riqjdh2oM?si=9mWgrsvOqI7uEJzj
- e. Superconductivity: https://youtu.be/CEUo9VswoVI?si=fdjd7-7yfFqZTS-M
- f. Quantum computing and the challenge of physical implementations (researcher's view): https://youtu.be/o10pogA3lao?si=BSvRFdGQ7x6gpkgu
- g. Example of Quantum computing implementation: NV diamond with point defect https://www.youtube.com/watch?v=VCT0wDLyvSs
- h. Q-ctrl resources for Quantum sensing
  https://q-ctrl.com/learning-center/advanced-topics