Introduction to Quantum Computing

Level: 3
Career Cluster: Digital Technology
Program: Information Technology
Pathway(s): Coding, Networking Systems and Security

Course Catalog Description

This course introduces students to the fundamental concepts of quantum computing and its applications in the Information Technology pathway. Students explore key principles such as qubits, superposition, and quantum circuits while examining real-world uses and career opportunities.

Summary

This course introduces high school students to the foundational concepts and emerging applications of quantum computing within the Information Technology career pathway. Students explore how quantum computing differs from classical computing by examining key principles such as superposition, entanglement, quantum measurement, and quantum circuits, while using real-world tools such as IBM Quantum Composer to model and visualize quantum systems. Through a combination of conceptual learning, hands-on activities, and applied problem-solving, students develop an understanding of how quantum technologies impact fields such as cybersecurity, healthcare, finance, and logistics. In addition to technical content, the course emphasizes career exploration, leadership, ethical reasoning, and work-based learning connections, enabling students to evaluate workforce opportunities and societal implications of quantum innovation. Students synthesize their learning through a capstone project, producing a professional-quality technology brief that communicates complex ideas to a non-technical audience, preparing them for continued study or entry into high-demand technology careers.

Notes

The updated course reflects a shift from a conceptual curriculum outline to a fully developed, standards-aligned instructional framework with clearly defined student learning outcomes, assessments, and CTE integration. The original course primarily focused on outlining quantum computing concepts, unit structures, and instructional resources, whereas the revised version formalizes these elements by organizing them into measurable student outcomes with aligned objectives for each content area, including career exploration, technical knowledge, ethics, and applications. The new document also introduces expanded components required for district submission, such as leadership, work-based learning, CTSO alignment, academic standards crosswalks, and structured assessment expectations, which were not explicitly defined in the original course outline. Additionally, the updated course strengthens career readiness by embedding workforce connections, postsecondary pathways, and real-world applications throughout the outcomes, rather than treating them as a separate component.

Student Learning Outcomes

1. Career Exploration and Postsecondary Opportunities

Objective: *Students will analyze career pathways in information technology, exploring industry roles, workplace expectations, required education, certifications, professional organizations, and postsecondary opportunities available in Colorado in order to make informed academic and career decisions.*

1) Name at least five distinct quantum career roles and describe the skills each requires.
2) Identify which quantum careers connect directly to the IT pathway and which require additional education in physics or engineering.
3) Map at least two quantum career trajectories from high school IT coursework through postsecondary options.
4) Describe what the current quantum job market looks like and what "quantum-adjacent" roles exist for non-physicists.
5) Identify at least two concrete next steps they could take (courses, programs, communities) to pursue quantum interest beyond this class
6) Define professionalism within the context of information technology
    a. Criticism and evaluation
    b. Presentation
    c. Assessment
7) Identify postsecondary opportunities offered in the state of Colorado
    a. Technical college, community college, 4-year institutions
    b. Certificates, associates, bachelor, and advanced degree opportunities

2. The Quantum Moment

Objective: *Students will develop foundational understanding of quantum computing concepts by analyzing the historical development of computing, distinguishing quantum computing from classical computing, and explaining the core domains of quantum information science in order to contextualize its relevance to modern technology and industry.*

5) Describe the historical arc from classical computing to quantum computing, identifying three key milestones.
6) Explain in plain terms why quantum computers are not just "faster classical computers."
7) Identify the three domains of quantum information science (computing, communication, sensing) and give a one-sentence description of each.
8) Connect quantum computing to at least two industries or problems students have encountered in Computer Science Foundations.

3. Superposition — Information in a New Key

Objective: *Students will analyze how information is represented in quantum systems by explaining the concept of superposition, comparing qubits to classical bits, and evaluating the implications of quantum measurement in order to understand how quantum computing processes information differently from classical systems.*

9) Explain superposition using a non-physics analogy that does not rely on Schrödinger's cat.
10) Describe how a qubit differs from a classical bit in terms of information representation.
11) Explain why superposition collapses upon measurement, and what that means for computing.
12) Identify at least one real-world implication of superposition-based computation.

4. Entanglement and Measurement

Objective: *Students will examine the principles of entanglement and quantum measurement by interpreting how quantum states interact and change upon observation, and evaluating their impact on information transfer and computation in order to explain key advantages and limitations of quantum systems.*

13) Explain entanglement using analogy, without reference to "teleportation" or "faster-than-light communication."
14) Describe what happens when a quantum measurement is made, and why this matters for computation.
15) Explain why entanglement does not allow information to travel faster than light.
16) Identify at least one application where entanglement provides an advantage (quantum key distribution, computation).

5. Quantum Computing — Circuits, Gates, and the Composer

Objective: *Students will apply foundational quantum computing concepts by constructing and analyzing quantum circuits using industry tools, comparing quantum gates to classical logic gates, and interpreting circuit outputs in order to demonstrate how quantum operations are designed and executed.*

17) Describe the function of a quantum gate and explain how it differs from a classical logic gate.
18) Navigate IBM Quantum Composer, add gates to qubits, and read basic output visualizations.
19) Build and run a Bell state circuit in IBM Quantum Composer and describe what it demonstrates.
20) Explain at a conceptual level why current quantum computers (the NISQ era) are powerful but noisy and limited.
21) Contrast superconducting qubit hardware with at least one other qubit technology at a conceptual level.

6. Quantum Communication and Quantum Sensing

Objective: *Students will explore real-world applications of quantum technologies by analyzing quantum communication and sensing systems, evaluating their advantages over classical systems, and explaining their impact on cybersecurity, data transmission, and emerging technologies.*

22) Explain quantum key distribution (QKD) and why it is theoretically more secure than classical encryption.
23) Distinguish between the quantum internet and the classical internet at a conceptual level. 3. Identify at least two real-world applications of quantum sensing.
24) Explain the cybersecurity relevance of quantum communication, specifically the "harvest now, decrypt later" threat.
25) Connect quantum sensing and communication to fields students are already familiar with (GPS, medical imaging, cybersecurity).

7. Applications, Algorithms, and What's Real Now

Objective: *Students will evaluate the current and future impact of quantum computing by analyzing key algorithms, identifying applicable problem types, and distinguishing between realistic applications and speculative claims in order to develop informed perspectives on emerging technologies.*

26) Explain at a conceptual level what Shor's algorithm and Grover's algorithm do (not how they work mathematically).
27) Describe the NISQ era and articulate why near-term quantum advantage is limited to specific problem types.
28) Identify at least three real-world industries or problems where quantum computing is expected to provide advantage.
29) Distinguish between genuine near-term quantum potential and speculative claims.
30) Explain what quantum simulation is and why it is considered one of the most promising near-term applications.

8. Society, Ethics, and Governance

Objective: *Students will analyze the societal, ethical, and economic implications of quantum technologies by evaluating risks, benefits, and governance structures in order to understand the broader impact of quantum computing on individuals, industries, and global systems.*

31) Explain the cryptographic risk posed by quantum computers and the current U.S. government response (NIST PQC standards).
32) Identify at least two workforce disruption scenarios created by quantum technologies.
33) Analyze equity-of-access concerns related to quantum computing, drawing parallels to historical technology transitions.
34) Describe the role of the National Quantum Initiative and at least one other governance mechanism.
35) Apply an ethical reasoning framework to a quantum technology scenario

10. Project: Quantum Technology Brief

Objective: *Students produce a structured, audience-ready deliverable that demonstrates synthesis across all six course learning goals. The project mirrors a real professional task: technology briefings that IT consultants, security analysts, and technology policy staff produce for non-technical decision-makers.*

35) Research and produce a written Quantum Technology Brief (structured document, approximately 2 pages)
36) Create a 5–7 minute oral presentation to the class, structured as a briefing to a non-technical audience (the class acts as stakeholders — a hospital board, city council, bank executives, etc., depending on the sector chosen)

11. Leadership

Objective: *Students will apply leadership skills in technology-focused environments by demonstrating effective communication, collaboration, problem-solving, and professional responsibility in both individual and team-based tasks.*

37) Demonstrate effective communication skills when explaining complex technical concepts to both technical and non-technical audiences.
38) Collaborate with peers to complete tasks, projects, and problem-solving activities related to quantum computing and information technology.
39) Apply critical thinking and decision-making strategies when analyzing technical challenges or emerging technologies.
40) Demonstrate accountability, time management, and responsibility in completing coursework and project-based assignments.
41) Reflect on personal strengths and areas for growth in leadership, teamwork, and professional behavior.

12. Work-Based Learning

Objective: *Students will connect classroom learning to real-world applications by analyzing industry practices, engaging in career-relevant activities, and demonstrating workplace readiness skills aligned to the information technology field.*

41) Identify how quantum computing concepts and technologies are applied in real-world industries such as cybersecurity, healthcare, finance, and logistics.
42) Analyze workplace expectations, including teamwork, communication, adaptability, and problem-solving in technology-focused careers.
43) Apply industry-relevant tools and practices (e.g., IBM Quantum Composer, research tools, data analysis) to simulate real-world tasks.
44) Evaluate case studies or real-world scenarios involving quantum technologies and propose appropriate solutions or responses.
45) Demonstrate readiness for workplace environments through professional communication, presentation, and project completion.

13. Career and Technical Student Organizations

Objective: *Using the CTSO Resource Document, chapter activities will provide some of the best opportunities CTSO members will have to learn by doing. A successful program of work creates a positive learning atmosphere in the classroom. CTSO members learn how to accept responsibility, work as a team, manage a budget, and handle success and failure. Per the CTE Admin Handbook, CTSOs are embedded into curriculum.*

Professional Development

Prepare each member for entry into the workforce and provide a foundation for success in a career. Becoming a professional does not stop with acquiring a skill, but involves an increased awareness of the meaning of good citizenship and the importance of labor and management in the world of work.

Community Service

Promote and improve goodwill and understanding among all segments of the community through services donated by CTSO chapters, and to instill in its members a lifetime commitment to community service.

Business and Industry Connections

Increase awareness of quality job practices and attitudes, and increase the opportunities for employer engagement and eventual employment.

Financial Leadership

Plan and participate in activities to allow all members to carry out the chapter's projects. Educate members on their own personal finance for current and future success.

Public Relations

Make the general public aware of the good work that students in career and technical education are doing to better themselves and their community, state, nation, and world.

Social Activities

To increase cooperation in the school and community through activities that allow CTSO members to get to know each other in something other than a business or classroom setting.

Academic Standards Alignment

Colorado CTE courses are required to integrate academic and essential skills into course content. The following academic standards have been identified as aligned to this course and should be integrated throughout instruction.

CO CTE Academic Standards Resources (Rubrics, integration strategies, etc)
CDE Colorado Academic Standards Online (Online standards lookup tool)

Note: Mathematics and Science standards will be added in the future. Visit the Colorado Academic Standards page for the most current version.

Reading, Writing and Communicating Crosswalk

Course: Introduction to Quantum Computing
Colorado Academic Standards – Reading, Writing, and Communicating

Standard	Prepared Graduate Competency	Description	Course Evidence / Alignment
Standard 1: Oral Expression and Listening	Prepared Graduate 1 – Collaboration	Collaborate effectively as group members or leaders	Students collaborate in discussions and group investigations to make sense of complex quantum concepts and problem-solving approaches.
Standard 1: Oral Expression and Listening	Prepared Graduate 2 – Oral Presentations	Deliver effective oral presentations	Students explain quantum principles, models, and applications through discussions or presentations tailored to varied audiences.
Standard 2: Reading for All Purposes	Prepared Graduate 4 – Informational Texts	Read a wide range of informational texts	Students read and interpret scientific, technical, and informational texts related to quantum

			computing and emerging technologies.
Standard 2: Reading for All Purposes	Prepared Graduate 5 – Language in Context	Understand how language functions in different contexts	Students use discipline-specific scientific and computing vocabulary and adapt explanations of abstract ideas for technical and non-technical contexts.
Standard 3: Writing and Composition	Prepared Graduate 7 – Informational Writing	Craft informational/explanatory texts	Students write explanations, summaries, and reflections that explain how quantum computing works and why it is significant.
Standard 3: Writing and Composition	Prepared Graduate 9 – Writing Process	Demonstrate mastery of the writing process	Students revise and refine written explanations of complex concepts to ensure clarity, coherence, and accuracy.
Standard 4: Research Inquiry and Design	Prepared Graduate 10 – Research and Ethics	Gather and ethically use information	Students research quantum technologies, evaluate source credibility, and consider ethical implications of advanced computing.

Free Resource Links

Self-Setup Requirements
Everything a student needs to start, independently:

- Free IBM Quantum account: Register at learning.quantum.ibm.com using a personal or school email address. Free tier is sufficient for all capstone work. No software installation required. Works on Chromebooks.
- IBM Quantum Composer: Accessible directly at quantum.cloud.ibm.com/composer. Basic circuit visualization runs without signing in (simulated, up to 4 qubits). Sign in to save work.
- Quantum Atlas: Accessible at quantumatlas.umd.edu. No account required.
- Quantum.gov: Accessible at quantum.gov. No account required.
- Document tool: Any browser-based word processor (Google Docs, Microsoft Office Online). No specialized software.
- Screenshot tool: Built-in OS screenshot (Windows Snipping Tool or Chromebook screenshot shortcut). Students save and insert into their document.

No instructor setup, no pre-built repository, no starter code, no accounts managed by the teacher.

Chromebook compatibility. Every tool required — Quantum Composer, Quantum Atlas, Quantum.gov, a browser-based word processor — runs without installation on a school Chromebook.

1. Career Exploration and Postsecondary Opportunities

Resource	Source	Type	Est. Time
Quantum.gov — Careers and Workforce	Quantum.gov	Reference reading	20 min
National Q-12 Education Partnership resources	Quantum.gov / Q-12	Reading + resource links	15 min
IBM Quantum Learning — Getting started pathway	IBM Quantum Learning	Learning pathway overview	20 min
Qubit by Qubit programs overview	The Coding School	Reference	10 min

Key Topics

- Quantum career taxonomy: hardware engineers, software/algorithm developers, quantum network engineers, security specialists, quantum data scientists, science communicators, policy analysts, salespeople/consultants
- Which roles require physics PhDs vs. which are accessible with a CS/IT background
- "Quantum-adjacent" roles: IT professionals who don't build quantum hardware but work with quantum-safe systems, quantum cloud infrastructure, or
- quantum-enabled applications
- Education pathways: community college certificates (e.g., Arapahoe Community College's CSC 1100 as a direct next step), university programs, IBM certifications, Qubit by Qubit programs
- Diversity in quantum: current state, barriers, and efforts to address them
- Real people in quantum: brief profiles emphasizing non-traditional and diverse pathways
- Next steps from the IT pathway: what courses and experiences build toward quantum readiness

Custom Content Needed

- Quantum career card set: 12 role profiles (1 per card), each with: job title, required background, day-to-day tasks, salary range, and one quote from a real person in the role
- IT pathway mapping diagram: visual showing which CSF and IT pathway courses build toward each quantum career cluster
- "Your quantum next step" planning tool: a structured one-page reflection where students identify one role they find interesting, one postsecondary step toward it, and one thing they can do before graduation
- Guest speaker guide: suggested questions, recommended speaker types, and instructions for arranging a free virtual Q&A with a quantum professional (IBM Quantum has community programs; Qubit by Qubit runs workshops)
- Optional stretch: instructions for finding and joining the IBM Quantum community or applying to a Qubit by Qubit program

Assessment

Career pathway plan (structured reflection, 1 page): Students identify one quantum career that interests them, trace a realistic educational path from their current IT coursework to that role, and write a paragraph explaining why this career appeals to them and what skills they already have that are relevant.

2. The Quantum Moment

Resource	Source	Type	Est. Time
Quantum Computing entry	Quantum Atlas / UMD	Visual explainer + audio	20 min
What is Quantum Computing? (IBM explainer)	IBM	Reading	15 min
National Quantum Initiative overview	Quantum.gov	Reference / reading	20 min
International Year of Quantum — IYQ 2025 resources	Quantum.gov	Video + reading	30 min

Key Topics

- What "quantum" means and where the word comes from
- Classical computing review: bits, logic gates, transistors (building on CSF prior knowledge)
- Why classical computing hits physical and computational limits
- The three QIS domains: computing, communication, sensing — brief survey
- The National Quantum Initiative and why the U.S. government considers this strategic
- Hype calibration: what quantum computers can and cannot do right now

Custom Content Needed

- Teacher background brief: "What do I need to know before teaching this unit?" (~3 pages, written for non-quantum teachers)
- Classical computing quick-review handout keyed to CSF prerequisites
- Domain-mapping activity: students sort real news headlines into computing / communication / sensing categories
- Unit 1 discussion protocol: "Where have you already encountered quantum — in movies, news, or games? What did they say it could do?"
- Formative exit ticket: written response explaining one thing quantum computers do differently than classical computers

Assessment

Short written response (2–3 paragraphs): Explain what quantum computing is to a family member who has never heard of it. Use at least one analogy and avoid jargon. Scored with a provided rubric emphasizing plain-language accuracy, not technical detail.

3. Superposition — Information in a New Key

Resource	Source	Type	Est. Time
Superposition entry	Quantum Atlas / UMD	Visual explainer + audio	25 min
Qubit entry	Quantum Atlas / UMD	Visual explainer	20 min
Quantum States entry	Quantum Atlas / UMD	Reading + interactive	20 min
Single systems — Basics of Quantum Information (conceptual intro)	IBM Quantum Learning	Course section (read-only, no code)	30 min

Key Topics

- The bit vs. the qubit: what changes and what doesn't
- Superposition as a spectrum of possibility, not "both at once"
- The Bloch sphere as a conceptual map (visual only — no trigonometry)
- What "coherence" means and why it is fragile
- Common misconceptions and how to address them

Custom Content Needed

- Analogy bank for teachers: 4–5 different analogies for superposition at varying levels of precision, with notes on where each analogy breaks down
- Misconception-busting pair activity: students encounter 5 common superposition misconceptions and decide true/false/partial-true with reasoning
- Visual: annotated Bloch sphere with plain-language labels (no math notation)
- Formative: "Explain it back" written prompt — students explain superposition without using the word "superposition"

Assessment

Comparative analysis: Students fill in a structured comparison table contrasting a classical bit and a qubit across four dimensions (states possible, behavior before measurement, behavior after measurement, real-world implication). Followed by a 1-paragraph written explanation of the most important difference.

4. Entanglement and Measurement

Resource	Source	Type	Est. Time
Entanglement entry	Quantum Atlas / UMD	Visual explainer + audio	25 min
Quantum Measurement entry	Quantum Atlas / UMD	Visual explainer	20 min
Quantum Cryptography entry	Quantum Atlas / UMD	Visual explainer	20 min
Multiple systems — Basics of Quantum Information (conceptual read)	IBM Quantum Learning	Course section (read-only)	30 min

Key Topics

- What entanglement is: correlated quantum states
- What entanglement is not: common misconceptions (FTL communication, "spooky action" as magic)
- Measurement collapse: why observing changes the state
- Bell states as a conceptual reference (no linear algebra)
- Entanglement as a resource: quantum key distribution (QKD) preview
- Why these phenomena require radically different hardware approaches

Custom Content Needed

- Teacher background brief: common student misconceptions about entanglement (FTL, telepathy, teleportation) and how to address each
- "Paired socks" analogy scaffolded discussion: students work through why correlated socks are *classical* correlation and what makes quantum entanglement different
- Scenario cards: students classify 6 proposed "quantum communication applications" as real / misconception / unclear, with reasoning
- Formative written prompt: "A friend says quantum computers can instantly send messages anywhere in the world using entanglement. How would you correct them?"

Assessment

Short written explanation (3–4 paragraphs): Explain entanglement and measurement collapse to a peer who just completed Unit 2. Your explanation must address one common misconception directly. Scored against a plain-language accuracy rubric.

5. Quantum Computing — Circuits, Gates, and the Composer

Resource	Source	Type	Est. Time
IBM Quantum Composer — browser tool	IBM Quantum Platform	Interactive lab tool	(primary lab environment)
Explore gates and circuits with the Quantum Composer	IBM Quantum Learning	Guided tutorial	45 min
Learn quantum computing: a field guide	IBM Quantum Learning	Reference reading (conceptual)	40 min
How to Make a Qubit entry	Quantum Atlas / UMD	Visual explainer	15 min

Key Topics

- Logic gates review (from CSF) → quantum gates as their quantum analogs
- The Hadamard gate: turning a classical bit into a superposition
- The CNOT gate: creating entanglement between two qubits
- Reading circuit diagrams: wires, gates, measurements
- IBM Quantum Composer: interface navigation, drag-and-drop circuit construction, output visualization panels (histogram, Q-sphere)
- The Bell state: why it is the "hello world" of quantum computing
- NISQ era: noisy intermediate-scale quantum — what it means that today's hardware is imperfect
- Hardware diversity: superconducting vs. trapped ion vs. photonic qubits (conceptual survey only)

Custom Content Needed

- Composer orientation guide for teachers: screenshots, where to sign up, what to do if a browser blocks anything, how to use the simulator (no account needed for basic use) vs. real hardware (account needed)
- Lab worksheet 1: Guided orientation — navigate the Composer interface, identify each panel, place a single gate, read the output
- Lab worksheet 2: Building a Bell state — step-by-step instructions with checkpoints and prediction prompts ("What do you expect the histogram to show before you run it? After?")
- Lab worksheet 3: Open exploration — students modify the Bell state circuit and record what changes, guided by reflection questions
- Classical logic gate review handout (bridge from CSF knowledge)

- NISQ era explainer one-pager written for high school reading level
- Hardware diversity visual comparison chart (no math, just: physical system, operating temperature, advantage, limitation)

Assessment
Lab report (structured template): Students document their Bell state circuit with a screenshot, explain in their own words what superposition and entanglement are visible in the output, and reflect on one thing that surprised or confused them. Followed by 3 comprehension questions scored for conceptual accuracy.

6. Quantum Communication and Quantum Sensing

Resource	Source	Type	Est. Time
Quantum Cryptography entry	Quantum Atlas / UMD	Visual explainer	20 min
What is Post-Quantum Cryptography? (NIST explainer)	NIST	Reference / plain-language explainer	20 min
Quantum.gov — Quantum Sensing overview	Quantum.gov	Reference reading	20 min
IYQ 2025 — What You Can Do With Quantum Science (video)	Quantum.gov / National Q-12 Partnership	Video	10 min

Key Topics
- Quantum Key Distribution (QKD): using measurement collapse as a security guarantee
- Why QKD is not the quantum internet (common conflation)
- The quantum internet: repeaters, entanglement distribution, current state of development
- Quantum sensing: clocks, gravimeters, magnetometers — applications in GPS, navigation, medical imaging (MRI), oil exploration
- The cryptographic threat: Shor's algorithm and RSA encryption (conceptual only)
- "Harvest now, decrypt later": the current real threat from adversarial data collection
- NIST Post-Quantum Cryptography standards (2024): what they are and why they exist
- Connection to cybersecurity prerequisite from CSF

Custom Content Needed

- Teacher background brief: QKD vs. quantum internet — the difference and why it matters
- Case study cards: 5 real-world quantum sensing deployments (atomic clocks in GPS, MRI, gravimetry for geology, magnetometry for brain imaging, quantum navigation for submarines) — students match each to a societal benefit
- Cryptography connection handout: bridges from CSF's CIA triad and encryption basics to the quantum threat — written for students who remember the CSF concepts but need the bridge
- "Harvest Now, Decrypt Later" discussion scenario: a fictional IT organization holds 10 years of sensitive customer data; students advise on response
- Formative: students write a 1-paragraph explanation of why QKD is more secure than classical key exchange, written for a bank's non-technical board of directors

Assessment

Two-part analysis: (1) Students read a short news excerpt about a real quantum sensing or communication application and write a structured response identifying the QIS domain, the quantum phenomenon enabling it, and one societal implication. (2) Short reflection: "Your CSF class covered encryption. What does the quantum threat change, and what doesn't it change, about how you think about cybersecurity?"

7. Applications, Algorithms, and What's Real Now

Resource	Source	Type	Est. Time
Quantum Computing entry — applications section	Quantum Atlas / UMD	Visual explainer	20 min
Shor's algorithm explainer — IBM Quantum Learning	IBM Quantum Learning	Course section (conceptual reading, no code required)	30 min
Grover's algorithm explainer — IBM Quantum Learning	IBM Quantum Learning	Course section (conceptual reading, no code required)	25 min
IBM Quantum roadmap (2025)	IBM Quantum	Reference	15 min

Key Topics

- Quantum speedup: why quantum algorithms are not universally faster

- Shor's algorithm: factoring and its implications for cryptography (conceptual narrative only)
- Grover's algorithm: searching through a database faster (conceptual — the "looking through a pile" analogy)
- Quantum simulation: modeling molecules for drug discovery and materials science
- Optimization problems: logistics, finance, supply chains
- The NISQ reality check: error rates, decoherence, limited qubit count
- Quantum advantage vs. quantum supremacy: terminology and the distinction
- Industry timeline: what is plausible in 5 years, 15 years, 30 years

Custom Content Needed

- Algorithm narrative cards: Shor's and Grover's algorithms told as stories (a lock-picking metaphor for Shor's; a spotlight-in-a-dark-room for Grover's) — without matrix algebra

- Industry application gallery: 8 cards, each describing a near-term quantum application in one sector, with a "hype-or-real" confidence rating and a brief rationale
- NISQ reality check activity: students read 4 claims made in tech news articles and annotate each as "supported by current evidence / overstated / accurate but distant"
- Timeline activity: students place 12 application milestones on a projected timeline, then compare to IBM's public roadmap
- Formative: "Pick one industry. What problem might quantum computing eventually solve there? What makes you confident this isn't just hype?"

Assessment

Comparative written analysis (2 short paragraphs): Choose one classical computing problem (from the list provided) and explain (1) how a classical computer would approach it, and (2) what a quantum computer might do differently and why that matters. No jargon, written for a general audience.

8. Society, Ethics, and Governance

Resource	Source	Type	Est. Time
NIST Post-Quantum Cryptography overview	NIST	Reference + plain-language reading	20 min
Quantum.gov — Policy and governance pages	Quantum.gov	Reference reading	20 min

QIST Workforce Development report (executive summary)	Quantum.gov	Reference (selected pages only)	20 min
NQI Annual Report FY2025 (selected sections)	Quantum.gov	Reference	15 min

Key Topics

- Cryptographic risk: why RSA and ECC are threatened and what NIST's 2024 PQC standards address
- The "harvest now, decrypt later" scenario as a present-day risk, not a future one
- Workforce disruption: jobs created, jobs transformed, jobs at risk
- Equity of access: who builds quantum technology, who benefits, who is left out — historical parallels with computing, AI, and the internet
- National Quantum Initiative: structure, goals, funding, international competition
- International competition and quantum sovereignty
- Governance gaps: who regulates quantum technology? What frameworks exist?
- Student agency: what role can IT professionals play in responsible quantum adoption?

Custom Content Needed

- Teacher facilitation guide: ethical discussion norms for technology topics; how to handle student misconceptions about economic disruption without causing anxiety or dismissiveness
- Ethical scenario card deck: 6 scenarios (e.g., a hospital using quantum sensing before the technology is fully validated; a nation-state that achieves quantum advantage but withholds it; a company that adopts NIST PQC standards vs. one that delays) — structured Socratic seminar format
- Equity deep-dive reading (custom): one-page accessible history of who built, who accessed, and who benefited from each of the last three major computing transitions (mainframes, PCs, internet), framed as a lens for quantum
- "Quantum Policy Briefing" template: structured note-taking guide students use while reading Quantum.gov policy pages
- Connection thread: how CSF's cybersecurity content connects to this unit (CIA triad revisited under quantum threat)

Assessment

Structured ethical analysis: Students select one quantum ethics scenario from the set provided. They write a 3-part response: (1) What is the ethical tension or risk? (2) Who is affected and how? (3) What should an IT professional or policymaker do? Scored against an ethical reasoning rubric that rewards evidence-based reasoning, not a "correct" position.

10. Project: Quantum Technology Brief

Sector Options
Students choose one sector to focus their brief:

- Healthcare (drug discovery, medical imaging, diagnostic sensing)
- Finance and banking (optimization, cryptographic risk, fraud detection)
- National security and cybersecurity (encryption, post-quantum migration, intelligence)
- Logistics and transportation (route optimization, supply chains)
- Environmental science and climate (materials simulation, sensing for environmental monitoring)
- Materials science and manufacturing (molecular simulation, new materials)

Brief Structure
Each written brief must include:

1. **The quantum opportunity or threat** — What is the relevant QIS capability (computing, communication, or sensing)? What problem does it address in this sector?
2. **How it works (conceptual)** — Explain the relevant quantum phenomenon (superposition, entanglement, or measurement) using at least one analogy. No math notation.
3. **Classical vs. quantum** — In 2–3 sentences, explain how a classical computer or classical technology currently addresses this problem and why quantum does it differently.
4. **IBM Composer circuit** — Include a labeled screenshot of a circuit built in IBM Quantum Composer that illustrates a relevant concept (Bell state, superposition of a single qubit, etc.). Write 2–3 sentences describing what the circuit demonstrates and how it connects to the sector application.
5. **Societal and ethical implications** — Identify at least two implications (positive and negative). Apply the ethical reasoning framework from Unit 7.
6. **Career connection** — Name one quantum career role relevant to this sector and the educational path toward it from a high school IT background.

11. Leadership

- Barclays LifeSkills Leadership Lesson Pack (leadership skills, teamwork, communication) https://barclayslifeskills.com/help-others/lessons/leadership/
- Lead4Change Student Leadership Program (project-based leadership, collaboration, problem-solving) https://lead4change.org/
- TEEN TRUTH Leadership Activities (student leadership activities, real-world application, teamwork) https://teentruth.net/student-leadership-activities/

- Teaching Expertise Leadership Activities (team-building challenges, communication exercises, collaboration)
  https://www.teachingexpertise.com/middle-school/leadership-activities-for-middle-school/

12. Work-Based Learning

- OCTAE Work-Based Learning Toolkit (WBL framework, career readiness, employer engagement)
  https://octae.ed.gov/wbltoolkit/
- Advance CTE Resource Center (CTE best practices, workforce alignment, program development)
  https://careertech.org/resource-center/
- CTE Toolkit – Leadership & Work-Based Learning (WBL definitions, CTSO integration, career readiness continuum)
  https://sites.google.com/icoeapps.org/ctetoolkit/lessons/leadership-work-based-learning
- Share My Lesson – CTE Resources (career exploration lessons, classroom-ready WBL activities)
  https://sharemylesson.com/subject/career-and-technical-education

Technology Student Association – National Competitive Events

Prepared Presentation

Objective: *Students will prepare and deliver an oral presentation with a digital slide deck on a contemporary STEM topic aligned with TSA Prepared Presentation competition requirements.*

- Research the annual TSA Prepared Presentation theme and connect it to science, technology, engineering, or mathematics.
- Develop a focused presentation that clearly communicates a central message related to the annual theme.
- Create a digital slide deck that enhances the presentation without distracting from the speaker.
- Organize content into a clear introduction, body, and conclusion.
- Practice professional speaking skills, including pacing, eye contact, vocal delivery, and transitions.
- Deliver the presentation within the required three-to-five-minute time limit.
- Evaluate presentations using TSA criteria for content, organization, delivery, slide deck quality, and connection to the theme.

Resources

- Technology Student Association – Prepared Presentation competition guidelines
  https://tsaweb.org/competitions-programs/tsa/themes-problems
- IBM Quantum Learning – Quantum computing learning resources
  https://learning.quantum.ibm.com/
- Quantum Atlas – Visual quantum science explainers
  https://quantumatlas.umd.edu/
- Canva – Presentation design tools
  https://www.canva.com/

Technology Student Association – National Competitive Events

Debating Technological Issues

Objective: *Students will research, document, organize, and defend evidence-based arguments about technological issues in alignment with TSA Debating Technological Issues competition requirements.*

- Research the annual TSA debate topic and related subtopics from credible sources.
- Prepare a one-page summary of references using MLA format according to TSA competition requirements.
- Develop evidence-based pro and con arguments for multiple technological issue subtopics.
- Organize claims, evidence, reasoning, cross-examination questions, and rebuttal points for timed debate rounds.
- Use clear, concise, and persuasive language appropriate for a formal debate setting.
- Respond to opposing arguments through questioning, analysis, and rebuttal.
- Evaluate debate performance using TSA criteria for research, argument quality, communication, reasoning, and professionalism.

Resources

- Technology Student Association – Debating Technological Issues competition guidelines https://tsaweb.org/competitions-programs/tsa/themes-problems
- National Institute of Standards and Technology – Post-Quantum Cryptography https://www.nist.gov/pqc
- Quantum.gov – National Quantum Initiative resources https://www.quantum.gov/
- Purdue OWL – MLA Formatting and Style Guide https://owl.purdue.edu/owl/researchandcitation/mlastyle/mlaformattingandstyleguide/

Technology Student Association – National Competitive Events

Data Science and Analytics

Objective: *Students will collect, analyze, visualize, document, and present a data set connected to the annual TSA Data Science and Analytics theme.*

- Research the annual TSA Data Science and Analytics theme and identify a focused topic for investigation.
- Collect or compile a data set of at least 500 rows from credible and relevant sources.
- Analyze data to identify trends, patterns, relationships, limitations, and possible predictions.
- Create a digital scientific poster that communicates the research question, data source, visualizations, analysis, and findings.
- Prepare a documentation portfolio explaining methods, data collection, analysis, conclusions, and resources.
- Present the digital scientific poster within the TSA time limit using clear, evidence-based communication.
- Complete an on-site semifinal challenge by creating a visual representation and brief synopsis from a provided data set.

Resources

- Technology Student Association – Data Science and Analytics competition guidelines
  https://tsaweb.org/competitions-programs/tsa/themes-problems
- IBM Quantum – Quantum roadmap and technology resources
  https://www.ibm.com/quantum/roadmap
- Google Dataset Search
  https://datasetsearch.research.google.com/
- Tableau Public – Data visualization tools
  https://public.tableau.com/