25 Project ideas for Pingry ISP 2027

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Physics and the nature of reality:

1. Theories of Everything. Can the fundamental forces and laws of physics fit into a single framework? Start with one successful unification, such as electricity and magnetism, and one unresolved problem. An illustrated explanation could compare what unification achieved with what a theory of everything would need to explain, distinguishing established evidence from proposed explanations.

2. Where Do the Rules of Physics Come From? Could familiar physical rules follow from a few assumptions about how observations combine? Use a simulation to explore a two-path interference experiment, comparing how probabilities and wave amplitudes combine. Change one assumption and examine the patterns, then explain which predictions you could test and which rules the model takes for granted.

3. Superfluidity and Superconductivity. How does quantum behavior become visible at everyday scales? Choose a phenomenon, such as frictionless flow or zero electrical resistance, and compare two systems. Superfluid helium, Bose-Einstein condensates, superconductors, and supersolids offer possibilities. Published observations or a simple model could reveal what they share and how they differ.

4. Quantum Computing. What makes quantum computation different from classical computation? You might explore one or two qubits through a small circuit, predicting its behavior and explaining the results. Use an existing simulator or build your own. Trying quantum hardware could extend the investigation; consider what your demonstration does and does not establish about quantum computing's promise.

AI, learning, and understanding:

5. Compression, Prediction, and Understanding. What can a learning system safely forget? Explore sequences with hidden patterns, comparing two ways of summarizing or predicting them. Then change the pattern or ask a new question of the same data. Can a summary predict well yet discard something important? Show where it remains useful and where it fails.

6. What Makes a Good Representation? Can changing how a problem is represented make it easier to learn? Compare raw pixels with features such as edges or symmetry in a small shape-recognition experiment. Use the same simple learning method, vary noise or orientation, and test unfamiliar examples. A gallery of successes and failures could reveal when a representation matters.

7. Movie Recommender. How can a recommender help someone discover a movie they might enjoy? With a small ratings dataset, compare popular choices with recommendations based on similar tastes. You might investigate unfamiliar films or viewers with little rating history, testing predictions against unseen ratings while asking what those scores reveal about enjoyment and discovery.

8. Who Checks the AI? How well can AI check its own work? Choose a task with independently checkable answers, such as short programs with known expected results. Compare self-review, another checker, and explicit tests using correct and deliberately flawed examples. Measure missed mistakes, false alarms, and effort, and investigate whether agreement between checkers actually indicates correctness.

Life, computation, and emergence:

9. DNA: Language, Software, Memory, Intelligence, or What? Is DNA best understood as software, memory, a language, or a blueprint? You might trace a protein-coding gene from DNA through RNA to protein, testing two metaphors along the way. An illustrated explanation or small model could show where the comparisons help and where they break down.

10. Self-Reference and Paradox. What happens when a statement or program refers to itself? Begin with one paradox or a program that prints its own source code. Create a demonstration or illustrated explanation of the central insight. Turing's halting problem or Gödel's incompleteness theorems offer deeper paths into the power and limits of self-reference.

11. Digital Universe Simulations. Can simple computational rules give rise to extraordinary complexity? Build a cellular automaton or another small simulated world, vary one rule, and observe how patterns emerge. Create a visual atlas or interactive experiment comparing the results, explaining how you recognize complexity and what your model can and cannot tell us.

12. Can a Program Keep Itself Alive? Could a program survive in a world with limited resources? Begin with a simple energy rule and compare two survival strategies across repeated trials. Memory, cooperation, or reproduction could make the world richer. Show how environmental changes affect which agents persist, and explore where the analogy with biological life breaks down.

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Networks, privacy, and trust:

13. Wireless Networking from Scratch with Audio. Can two computers exchange messages through speakers and microphones? Build a small acoustic modem, perhaps starting with two tones and a short message. Measure errors as noise or distance changes, then explore synchronization or error correction to improve reliability.

14. Distributed Systems. How can computers cooperate when messages arrive late or machines fail? Simulate a few computers on one machine and try keeping a shared record consistent. Demonstrate a failure, compare possible responses, and explain the tradeoffs.

15. Blockchain for School. Would a school problem benefit from a blockchain? Use fictional club records to compare an ordinary database with a small blockchain prototype. Demonstrate the differences and explain whether decentralization adds enough value to justify its complexity.

16. Cryptography. How can people establish trust over an insecure network? Choose one concept, such as digital signatures detecting altered messages, for an interactive demonstration or educational prototype. Explain what it protects and which assumptions it relies on; zero-knowledge proofs offer another direction.

17. Anonymizing Data. How anonymous is "anonymous" data? Create fictional records, remove names, and investigate whether other clues reveal identities. Compare ways to protect privacy while preserving useful answers, perhaps exploring aggregation, added noise, or differential privacy. Explain the tradeoffs your experiment reveals.

Money, work, and social impact:

18. From Clay Tablets to Bitcoin: The Technology of Money. What is money, and how have people used technology to represent value, record obligations, and establish trust? Compare two or three examples, such as ancient tablets, paper money, and cryptocurrencies. Investigate the problems each addressed and who controlled the records. Present your findings through an essay, exhibit, or annotated timeline.

19. Quantitative and Systematic Investing. How can you tell whether an investment strategy works, or merely looks good in hindsight? Compare one rule with a benchmark using historical data, including trading costs and a separate period for evaluation. A spreadsheet is enough to begin. Explain what the evidence supports; a strategy's failure can be an informative result.

20. AI, Careers, and a Rapidly Changing World. How can seniors at Pingry make sense of AI and their future working lives? Choose one or two occupations, examine how particular tasks might change, and compare predictions with available evidence. Use interviews, reading, or reflection to create a guide for fellow students, acknowledging anxiety, uncertainty, and practical ways to prepare.

21. Technology and Not-for-Profits. How can technology help a nonprofit pursue its mission? Consider Pingry or another local nonprofit: identify one practical need and explore possible improvements. Crypto for Charity, which converts crypto donations to cash for designated charities, offers one example. Develop a prototype, workflow study, or recommendation, considering whether a simpler approach would work better.

Evidence, uncertainty, and judgment:

22. Can You Tell What Causes What? When two things change together, how can you tell whether one causes the other? Create a small simulated or tabletop world with hidden rules, then compare observing it with intervening in it. Design experiments to distinguish competing explanations within a limited budget. Show when more observations help and when a different experiment is needed.

23. Seeing More by Measuring Less. How can a few measurements reveal an image or sound? Start with a tiny image or short sound, using an existing reconstruction tool or a method you build. Change the measurement count or noise. Create a gallery comparing originals and reconstructions, including convincing mistakes, and explain which assumptions make recovery possible.

24. Can the Average Win While Most Players Lose? Simulate a token game where each independent fair coin toss adds 50% to a player's balance on heads or removes 40% on tails. Compare the expected average, simulated mean, median, and individual histories using a spreadsheet or code. Explain the role of rare outcomes, then explore changing stakes or sharing resources.

25. When Does a Crowd Become Wise? When does listening to others improve judgment, and when does it create an echo chamber? Build a model where decision-makers receive incomplete clues about a question with a known answer. Change one communication rule, compare accuracy with agreement, and explain what your model can and cannot reveal about real groups.