# *Introduction to Computer Science 1st edition Franchitti Solutions Manual*

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INSTRUCTOR ANSWER GUIDE

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# Introduction to Computer Science

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# OpenStax *Introduction to Computer Science* Instructor Answer Guide

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# Chapter 1: Introduction to Computer Science

## Review Questions

1. What is computer science?

[Answer: Computer science is the study of computing, which includes all phenomena related to computers, such as the Internet. With foundations in engineering and mathematics, computer science focuses on studying algorithms, which are instructions that enable computing. This includes computer hardware and software and the way these are used to process information.]

2. What two subjects does computer science combine the foundations of?
    a. math and engineering
    [Correct. Computer science principles are built on mathematic concepts and engineering techniques are applied to advance computational technology over time.]
    b. math and physics
    [Incorrect. Computer science is based on the concepts of mathematics, but not directly physics. It could be argued that hardware design applies the laws of electricity, but that would only apply to hardware and not the general concepts of digital computations.]
    c. physics and engineering
    [Incorrect. Computer science is based on the concepts of engineering, but not directly physics. It could be argued that hardware design applies the laws of electricity, but that would only apply to hardware and not the general concepts of digital computations.]
    d. math and chemistry
    [Incorrect. Computer science is based on the concepts of engineering, but not chemistry.]

[Answer: A]

3. What can execute an algorithm?

[Answer: Human computers, which were common before the 1950s, and digital computers, which can execute computer programs that represent algorithms.]

4. What enables the ENIAC (one of the first digital computers, invented in 1945) to be able to compute anything that can run on modern computers?
    a. Both the ENIAC and modern computers have memory.
    [Incorrect. Although it is true that both the ENIAC and modern computers have some way of representing memory, memory alone doesn't explain how the ENIAC can compute the same things as modern computers. What is common between the ENIAC and modern computers is their shared common approach to manipulating information stored in memory in a consistent way.
    b. Both the ENIAC and modern computers share the same hardware.
    [Incorrect. The ENIAC used vacuum tubes to represent memory, whereas modern computers use silicon.]
    c. Both the ENIAC and modern computers are considered Turing-complete.
    [Correct. Because the ENIAC is Turing complete, it can compute anything that can run on modern computers.]
    d. Both the ENIAC and modern computers run the same software.
    [Incorrect. Not necessarily. Software is written for programming languages that are specific to computer systems or computer architectures. Software has advanced a lot



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since 1945, so the techniques and programs for modern computers likely won't run directly on an ENIAC. However, we can rewrite those programs for the ENIAC.]

5. What invention was credited as the first calculator?
   a. punch cards
      [Incorrect. Punch cards were invented in the 1890s.]
   b. abacus
      [Correct. The abacus was a device that was considered the first calculator.]
   c. Difference Machine
      [Incorrect. The Difference Machine was invented in the 1620s.]
   d. ENIAC
      [Incorrect. The ENIAC was the first computer, but it was not considered the first calculator.]

[Answer: B]

6. What term is considered an algorithm that can be run on a computer?
   a. artificial intelligence
      [Incorrect. Artificial intelligence is defined as the development of computer functions to perform tasks, such as visual perception and decision-making processes, that usually are performed by human intelligence.]
   b. algorithm
      [Incorrect. Algorithm is defined as a sequence of precise instructions.]
   c. computer program
      [Correct. A computer program is defined as algorithms that can be run on a computer.]
   d. programming language
      [Incorrect. A programming language is defined as a language consisting of symbols and instructions that can be interpreted by a computer.]

[Answer: C]

7. Why is computer science often not considered a science?
   a. Computer science does not study natural objects.
      [Correct. It is not considered a natural science because it does not study natural objects or phenomenon.]
   b. Computer science emphasizes the discovery of natural phenomena.
      [Incorrect. The natural sciences, not computer science, emphasize discovery of natural phenomena.]
   c. Computer science is spreadsheet-based.
      [Incorrect. While spreadsheets are important in computer science, this has nothing to do with whether computer science is regarded as a science.]
   d. Computer science focuses on computational structures.
      [Incorrect. While computational structures are important in computer science, this has nothing to do with whether computer science is regarded as a science.]

[Answer: A]

8. What is the definition of data science?
   a. a subfield of computer science that emphasizes the social aspects of computation



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[Incorrect. This defines human-computer interaction.]

b. an interdisciplinary field studying information technologies and systems as they relate to people, organizations, and societies
[Incorrect. This defines information science.]

c. a subfield of computer science that emphasizes how problems can be solved with computers as well as the practices and processes that can help people design more effective software solutions
[Incorrect. This defines software engineering.]

d. an interdisciplinary field that applies computing toward managing data and extracting information from data
[Correct. This is the definition of data science.]

[Answer: D]

9. What term is used to describe a subfield of computer science that emphasizes how a computational problem can be defined in mathematical terms and whether that mathematical problem can be efficiently solved with a computer?
   a. computational science
   [Incorrect. Computational science is defined as the application of computing concepts and technologies to advance scientific research and practical applications of science knowledge.]
   b. theoretical computer science
   [Correct. Theoretical computer science is defined as a subfield of computer science that emphasizes how a computational problem can be defined in mathematical terms and whether that mathematical problem can be efficiently solved with a computer.]
   c. information science
   [Incorrect. Information science is defined as an interdisciplinary field studying information technologies and systems as they relate to people, organizations, and societies.]
   d. data science
   [Incorrect. Data science is defined as an interdisciplinary field that applies computing toward managing data and extracting information from data.]

[Answer: B]

10. What subfield of computer science relates information technology to people and society?
    a. computational science
    [Incorrect. Computational science is defined as the application of computing concepts and technologies to advance scientific research and practical applications of science knowledge.]
    b. theoretical computer science
    [Incorrect. Theoretical computer science is defined as a subfield of computer science that emphasizes how a computational problem can be defined in mathematical terms and whether that mathematical problem can be efficiently solved with a computer.]
    c. information science
    [Correct. Information science is defined as an interdisciplinary field studying information technologies and systems as they relate to people, organizations, and societies.]
    d. data science



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[Incorrect. Data science is defined as an interdisciplinary field that applies computing toward managing data and extracting information from data.]

[Answer: C]

11. How does computational science contribute new methods to the study of the sciences?

[Answer: Answers may vary. Computational science incorporates computation in the study of the sciences. Rather than relying on direct experiments of phenomena to discover knowledge, computational science introduces simulation and computer modeling as new tools to advance scientific research and development. For example, we can design computer models that simulate protein folding behavior. These simulations can then be verified in the real world. Once the simulations are sufficiently effective, they can be relied on for advancing discoveries in medicine, energy generation, climatology, and other applications of scientific knowledge.]

12. How do information science and computer science compare?

[Answer: Answers may vary. Information science and computer science share significant overlap because computer science deals with data that often encode information relevant to people, organizations, and societies. However, computer science often focuses more on the computational side of things. Computer scientists might emphasize questions such as, "How can or should this data be transformed?" Information scientists might emphasize questions such as, "How do people use this data to inform policies or decisions?" Often, the answers to these questions are interrelated and connected especially because algorithms and computation are now deeply embedded in and affecting people, organizations, and societies.]

13. What does it mean to say that the various areas of computer science are synergistic?

[Answer: Computer science is an interdisciplinary field that has the ability to shape other disciplines. It is used around the world by people in diverse capacities. For example, in theoretical computer science, the focus is on functions like computations, data structures, algorithms, programming, while the computer systems of computer science focus on things like artificial intelligence, networks, databases, and security. Then, applied computer science looks at human-computer interactions. Computer science is a complex field and its synergistic nature means that when computer science is used in an interdisciplinary manner that shapes other disciplines, the impact on society is much greater than when each discipline functions on its own.]

14. What term is defined as an approach that emphasizes people rather than technologies in the design of computer solutions?
    a. human-centered computing
       [Correct. This is the definition of human-centered computing.]
    b. neural network
       [Incorrect. Neural network is defined as an AI algorithm architecture that emphasizes connections between artificial "neurons" whose behavior and values change in response to stimulus or input.]
    c. social determination of technology
       [Incorrect. Social determination of technology is defined as the belief that technologies are inherently neutral, and that it is the people who use a technology who ultimately make it "good" or "bad."]



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d. technological fix
[Incorrect. Technological fix is defined as an idea that technologies can solve social problems, but now is often used to critique blind faith in technological solutions to human problems.]

[Answer: A]

15. A software application takes an image as an input and analyzes it. This is an example of what?
    a. illustrative processing
    [Incorrect. This is not a term covered in this chapter.]
    b. image recognition
    [Correct. The definition of image recognition is the problem of identifying objects in an image.]
    c. image generation
    [Incorrect. While this is a capability of artificial intelligence, this refers to the generation of an image, not the analysis of an existing image.]
    d. analytical modeling
    [Incorrect. This is not a term covered in this chapter.]

[Answer: B]

16. What are adversarial attacks and why is it important to study them?

[Answer: Answers may vary, but could define adversarial attacks as sample inputs (e.g., images) that are designed to cause a system to behave problematically. Answers could explain that the problems caused by adversarial attacks may include things like causing a neural network to report extremely high confidence in its wrong answers. By studying adversarial attacks, researchers can design neural networks that are more robust and resilient to these attacks.]

17. What is the relationship between artificial intelligence, image recognition, and neural networks?

[Answer: Image recognition is a problem that can be solved with the help of artificial intelligence approaches such as neural networks.]

18. How do neural networks recognize objects in images?

[Answer: Neural networks are an AI architecture that is inspired by the biology of neurons in a brain. In a computer, “neurons” are represented as numbers that can be combined mathematically to memorize patterns in images. With enough numbers, the neural network can learn to memorize the patterns of edges representing an object as it appears across many different perspectives and situations.]

## Conceptual Questions

1. Give two definitions of computer science. How do they compare?

[Answer: Newell, Perlis, and Simon defined computer science as “the study of the phenomena surrounding computers.” This is a very inclusive definition that enables all people studying computers and their implications to be part of computer science. Others prefer more exclusive definitions of computer science that emphasize how computers can solve problems. This second perspective tends to minimize the contributions of people who want to understand all the ways computing is changing the world.]

2. Explain the concept of theoretical computer science.



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[Answer: Theoretical computer science focuses on the mathematical processes behind software. It expands computer science knowledge by contributing ideas about (1) whether a result can be computed by a Turing-complete computer at all, (2) how that result might be computed using an algorithm, and (3) how quickly or efficiently a computer can run such an algorithm.]

3. What is body-syntonic reasoning and how has it affected education?

[Answer: Body-syntonic reasoning, an idea from Papert, refers to a kind of experience that could help students more effectively learn concepts in mathematics and physics by constructing their own understandings via reasoning through the physical motion of turtle programs. In this way, computers could not only be used to further education in computer science, but also offer new, more dynamic ways to learn other subjects. Papert's ideas have been expanded beyond the realm of mathematics and physics to areas such as the social sciences, where interactive data visualization can help students identify interesting correlations and patterns that precipitated social change and turning points in history while also learning new data fluencies and the limits of data-based approaches.]

4. In terms of data science, what is a spreadsheet and why can it be said that by using spreadsheets, people are programming without realizing it?

[Answer: Answers may vary. A spreadsheet is an example of a data-centric programming environment where data is organized into cells in a table. Instead of presenting programs as primarily about algorithms, spreadsheets present programs as primarily about data. Spreadsheets are often used for data analysis by offering a way to organize, share, and communicate ideas about data. Spreadsheets are uniquely effective and accessible because they allow for visual organization of data in whichever structure makes the most sense to the user. Instead of hiding data behind code, spreadsheets make data as transparent and up to date as possible. Millions of people use spreadsheets daily, and because spreadsheets are a form of computer programming, these people are programming without realizing it.]

5. How do discovery and invention differ and how are these involved in computer science?

[Answer: Answers may vary. Discovery is often associated with the natural sciences like biology and physics, which discover natural phenomena. Invention is creation or engineering, and it is not focused on natural phenomena. Computer science involves discovery in the physical and mathematical principles underlying computation. Computer science involves invention in the creative design work behind creating software or hardware systems based on these principles.]

6. Describe in your own words the difference between data (as in data science) and information (as in information science). How does computer science shape both fields?

[Answer: Answers may vary. Data can refer to facts, statistics, or figures drawn from some source. Information can refer to the findings or insights analyzed from data. Computer science shapes both data science and information science by providing methods for organizing and analyzing data as it is transformed from raw forms into information that can be used to shape a decision.]

7. Give a real-life example that refutes social determination of technology. Your example does not need to involve computing, but it should involve some technology designed by humans.



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[Answer: Answers may vary. An example from science and technology studies is nuclear energy: "if you accept nuclear powerplants, you also accept a techno-scientific-industrial military elite. Without these people in charge, you could not have nuclear power."(Mander quoted in Winner 1980). Another example closer to daily life could involve roads and public infrastructure: the prioritization of individually owned vehicles over public transit is shaped by the way that roads and highways are prioritized in the United States. Even before these roads are used by people, the design of road networks in the United States prioritizes travel by individual vehicle owners. However, not all people own cars, and the people who do own cars are not representative of everyone in the United States.]

8. Artificial intelligence approaches are typically used to solve problems that requires specific kinds of "intelligence." Describe a real-life computational problem or application that *does not* need artificial intelligence.

[Answer: Answers may vary. One example is spreadsheet software, which focuses on working with the user to organize and layout data. Yet even in the case of spreadsheets, AI approaches are helpful to support the user in analyzing and uncovering patterns in the data by generating visual representations of the data and statistics. Another example could be a shopping app that might involve handling shopping transactions over the Internet and communicating with the business owner's server.]

9. Image recognition systems that can detect objects in images enable self-driving cars and many large-scale manufacturing or agricultural operations. Give another example where image recognition could be used as part of a larger system to automate decisions at scale.

[Answer: Answers may vary. Image recognition could be used in consumer or professional medical diagnoses, such as by enabling an app to recognize diseases from photos of patients. It could also be used to help consumers repair products by identifying needed replacement items or assist people with vision disabilities in navigating the physical world.]

## Practice Exercises

1. Research where the term *debugging* originated from and why it refers to finding problems in our programs today.

[Answer: In 1947, in the very early days of computing, Grace Hopper who worked for Harvard University found a literal bug in the mainframe of the computer that caused the computer to not work correctly. She referred to the removal of the bug and therefore fixing the problem, as debugging. The term is still widely used as a way to describe finding "bugs" in computer systems and fixing them.]

2. Research some examples of computational models and how they are a part of everyday life.

[Answer: Answers will vary. A sample answer is as follows: The weather forecast is simply predictions based on computer models of the atmosphere over time and how weather patterns will interact with changes in the atmosphere. There are several different models that run simulations to piece together a weather pattern to determine a forecast.]

3. Research how computational models relate to mathematics.

[Answer: Answers will vary. A sample answer is as follows: Many models are based on mathematical formulas. Many models are mathematical formulas implemented in algorithms that models run to perform simulations.]



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4. Research some examples of how artificial intelligence is used across multiple industries. Summarize at least two different industries and how AI is currently being used.

[Answer: Answers will vary. A sample answer follows: In finance, systems are being developed to analyze large amounts of real-time quantitative data to improve models of financial forecasting related to trading and macroeconomic trends. In health care, systems are being developed to help diagnose common and uncommon health conditions faster.]

5. Research ethical issues related to artificial intelligence and provide an example of how artificial intelligence can be misused for unethical and even criminal ways.

[Answer: Answers will vary. A sample answer follows: Artificial intelligence can generate data of many formats. Fake images that can be used to represent misinformation is one way AI can unfortunately be used in unethical ways.]

## Problem Set A

1. Research examples of how modeling and simulations have led to new inventions and discoveries.

[Answer: Modeling and simulations are used in almost every field of engineering ranging from research and development to testing new technologies and designs. In the automotive industry, many new safety features were designed and then evaluated using modeling and simulations prior to physical crash testing. This saves the industry millions of dollars by proving out concepts prior to expensive crash testing.]

2. Research and provide a summary of the difference between artificial intelligence and machine learning.

[Answer: Artificial intelligence encompasses the idea that a machine can mimic and develop intelligence and cognitive abilities similar to humans. Machine learning aims to teach algorithms to improve over time by identifying patterns.]

## Problem Set B

1. Research how artificial intelligence and machine learning can improve the accuracy of computational models and lead to cutting-edge technology inventions in the future. Provide a specific example of how AI and ML have been used in this way so far.

[Answer: Artificial intelligence was used during the development process of the COVID-19 vaccine by Pfizer. The company relied on modeling and simulation paired with artificial intelligence to rapidly speed up development of a new vaccine.]

2. Research and provide a summary of how machine learning is a subset of artificial intelligence and plays a key role in artificial intelligence systems.

[Answer: Machine learning is the ability to learn over time and therefore provides the system with the intelligence aspect of AI. It is the key enabler for the system to learn and adapt in its operational environment.]



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## Thought Provokers

1. Corporate social responsibility is the idea that businesses have a responsibility to society, including the areas of environmental responsibility, ethical responsibility, philanthropic responsibility, and economic responsibility. Given the contentious history of computer science and computer technologies, what can businesses (or businesspeople) that wish to employ a "disruptive" computer technology do to ensure corporate social responsibility?

[Answer: Answers may vary. Disruption often occurs at the expense of other people's livelihood. The business might first analyze their purposes and intentions for employing technology. Is it only designed to create a competitive advantage without regard for human values, benefits, or harm? Or is it designed to advance the dimensions of corporate social responsibility? Although technologies are rarely purely beneficial or purely harmful, understanding the underlying purposes for advancing a technology can help businesses center (or decenter) corporate social responsibility. Has the business done a holistic analysis of the impacts? A common yet problematic ethos that dominated the booming tech start-up industry in Silicon Valley was the tagline, "move fast and break things," valuing technological advancement at any cost.]

2. Computer technologies like the Internet have changed everyone's lives, regardless of whether they use the Internet directly or not. Yet, with computer technologies, the future is rarely certain. How can a business stay relevant and profitable in the face of new technologies while ensuring corporate social responsibility? In what ways does ensuring corporate social responsibility create economic value and more diverse kinds of value?

[Answer: Businesses can build profit through corporate social responsibility, not despite it. For example, investing in risky, new computer technologies might lead to more environmentally sustainable solutions. We are seeing today, for example, large-scale concerns around energy companies that refuse to transition to clean energy futures. Companies that build public trust through their corporate social responsibility are also broadening their customer base. Corporate social responsibility can also improve employee engagement and effectiveness as people—both employees and customers—seek companies that center social good in their missions.]

3. Give a real-life public policy problem involving a computer technology or dataset and use it to illustrate differences between the fields of data science, information science, and computer science.

[Answer: Answers may vary. One sample situation involves identifying food deserts (areas where residents have limited access to affordable healthy food options) to determine how to allocate government funding for new grocery stores or food banks. Data scientists might ask questions about how the data was collected and whose perspectives it reflects, what kinds of analyses could be performed to gain insights into the data, and how data can be visualized. Information scientists might ask questions about how the data analyses inform solutions or policies: How does a visualization produced by a data scientist fit in with testimonies sourced from local communities, market conditions and incentives from potential store owners, and public transit infrastructure to support residents in traveling to these new resources? Computer scientists might ask questions about what kinds of new foundational technologies could be applied toward all these questions raised by data scientists and information scientists and how the choice of technologies can shape social outcomes or decision-making.]



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4. Mathematics is one of three perspectives that computer scientists use to design, analyze, and evaluate computational structures, systems, and processes. However, mathematics is often regarded as an abstract or "pure" field of study that is not involved in social or political concerns. How might computer science's ability to automate and represent problems in mathematical terms have social or political consequences?

[Answer: Answers may vary. The way that a problem is represented using mathematics in computer science encodes values(often social or political in nature). For example, representing students in terms of their average grades in a gradebook reduces people down into a single number for ease of analysis, sorting, comparison, or ranking. The use of an average grade assumes that all of a student's grades are equally important, even though some might argue that learning occurs, so grades at the end of schooling are more important and reflective of a student's understanding than grades at the beginning. Brian Cantwell Smith suggests that "it would not be too much to say that every act of conceptualization, analysis, categorization, does a certain amount of violence to its subject matter, in order to get at the underlying regularities that group things together."]

5. The future of society will be shaped by the *philosophy* of computer science and people's purposes, motivations, and political values. Give another philosophy that might influence or affect how computer scientists go about creating solutions.

[Answer: Answers may vary, but could connect to the established history of computer science. For example, one constant value in computer science is an emphasis on efficiency, a neoliberal goal related to productivity that traces back to the earlier industrial revolution. Today's information age seems to be shaping the future of work around producing more and more value from the same or even less raw materials or workforce. This philosophy seems at odds with the ability of computer science to improve human happiness and raises a tension between technology and the people they serve. Does technology exist to make life better for people? If so, our current approach seems to be asking more from humans than before, despite promises of robots and automation.]

6. If your organization is interested in artificial intelligence technology to enhance operations, what could you do to ensure the system is designed and implemented in a safe, socially responsible, and just manner?

[Answer: Answers may vary. We might first consider the purpose of technology: AI technologies tend to enable increased efficiency of existing processes by automating certain kinds of intelligence. This automation comes at certain costs. One issue is that the automation is not truly intelligent—it may be able to make decisions that are responsive to the input, but the algorithm is not truly "thinking" on its own. Another is that we might become overly dependent on (or trusting of) the system's decision-making simply because it is a computer. Before deploying or even designing the system, we can involve people in the process: not only people directly benefiting from or harmed by technology, but also by all the people who will be supporting from the sidelines or affected indirectly by it. We should apply human-centered design practices.]



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