

Weekly Problem Set #1 – Week 1

PLEASE SHOW ALL YOUR WORK FOR FULL CREDIT. Showing your work includes writing out intermediate steps in ways that others can understand or writing sentences that help to communicate your assumptions and logic. If you utilize any software tools or apps (e.g. Mathematica, Desmos, ChatGTP, etc.), you must transparently acknowledge your use of them in your HW submission. A subset of these problems will be graded for correctness. The rest of the problems will be graded for effort.

Part 0: Getting to Know One Another

Question 0 (4 pts). Create a slide about yourself. Make a copy of the template slide and fill it in with information about yourself (including a recent photo). This slide deck will be shared with the entire class and teaching team, please include only respectful content. This tool will help us to learn each other's names and interests. https://docs.google.com/presentation/d/1yt7_-M0T-JwqQaFYMnNyqJJ0lYRmGTvukeQdNRVdblw/edit?usp=share_link

Part 1: Combinatorics. Let's review combinatorics by warming up with everyday examples (e.g. coin, die). Our reasoning about these simple systems will serve us well in making sense of classical two-state physical models (e.g. a switch being on/off, a disc's surface being a pit/land, or a voltage read as 0V or 5V). We can represent these systems using binary digits: 0 or 1.

Question 1 (4 pts). (adapted from Wong, E1.1). Imagine you have a fair coin that can be either "heads" or "tails" (a simple two-state system). How many possible states do (i) four coins have? (ii) five coins have?

Question 2 (4 pts). (adapted from Wong E1.2). Imagine a fair 6-sided die that can give a 1, 2, 3, 4, 5, or 6. How many possible states do (i) four die have? (ii) five die have?

Question 3 (4 pts). (Wong E1.4). How many (a) coins and (b) six-sided dice would it take to represent the 26 letters of the English alphabet? Ignore upper and lowercase, spaces, punctuation, etc., so there's only 26 letters total.

Part 2. Counting in Binary (Base 2). Let's practice counting in binary (or base 2), as we will use this notation to label two-level quantum states.

Question 4 (6 pts). (Wong E1.5). Convert the following binary numbers (base 2) to decimal numbers (base 10):

- 10111₂.
- 11001010₂.
- Choose one six-digit binary number and convert it to a decimal number (in base 10)

Question 5 (6 pts). (Wong E1.6). Convert the following decimal numbers (base 10) to binary numbers (base 2):

- (a) 42
- (b) 495
- (c) Choose an additional two-digit decimal number (base 10) to convert to binary (base 2)

Part 3. Logic Gates

Question 6 (6 pts) (Wong E1.11). Explain your reasoning and justify your answers.

Question 7 (6 pts) (Wong E1.12). Explain your reasoning and justify your answers.

Question 8 (6 pts) (Wong E1.19). Explain your reasoning and justify your answers.

Part 4. Developing your quantum interests. The purpose of this task is to help you explore or develop your quantum interests and share those interests with the Phys360 instructional team. This task will be the beginnings of your course project this semester, so pick something that you'd like to dig into more deeply as part of a course project this semester.

Question 9 (6 pts). Find a popular science article about quantum phenomena or quantum technology that is of interest to you. Read this piece. Turn in: (a) a full APA-style reference to the article that you read, (b) a written one-paragraph summary of the main idea(s) and (c) a list of additional questions that this piece raises for you. *Note: The article that you summarize will guide the topic that you are assigned to explore for your course project, so make sure to choose a topic that you would like to explore more deeply this semester.*

- Here are some suggested publication venues to consider:
 - New Scientist: <https://www.newscientist.com>
 - Scientific American: <https://www.scientificamerican.com>
 - Physics Today: <https://pubs.aip.org/physicstoday>
 - Nautilus: <https://nautil.us>
 - Symmetry: <https://www.symmetrymagazine.org/>
 - Quanta Magazine: <https://www.quantamagazine.org/>