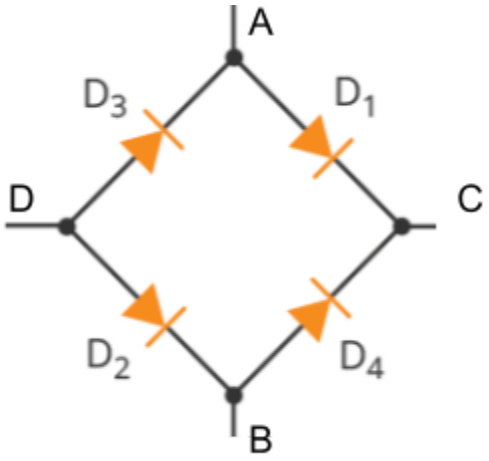
Name:_____ Student ID:_____

CICS 256 Midterm (S25)

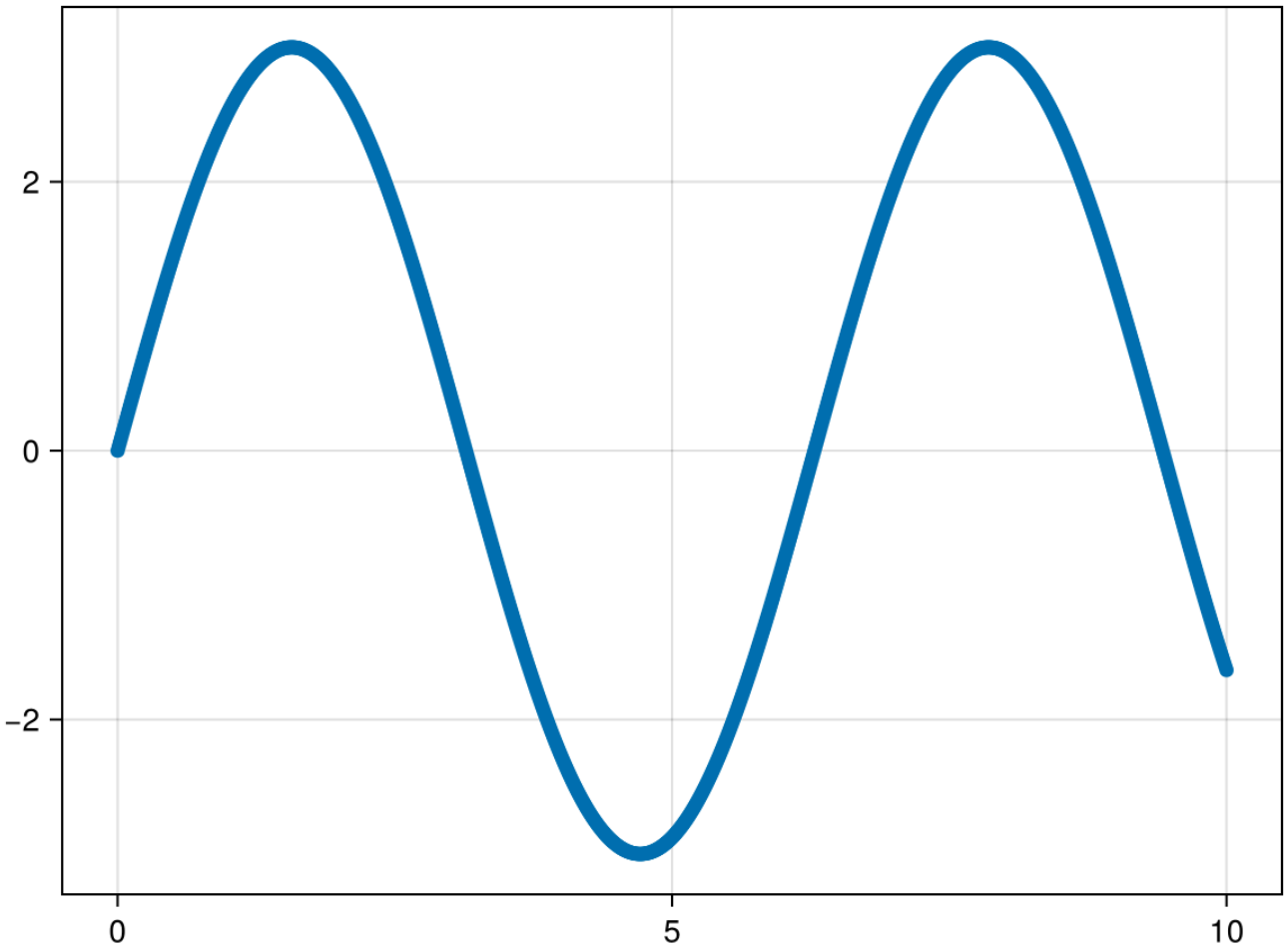
Instructions:

- **No questions will be answered by the proctor during the exam. If you consider a question unclear, describe your best interpretation of the question and solve for it. If you believe there is a mistake in the problem statements, just note so in your solutions. No mistakes have been planted on purpose in this exam.**
- **This is a closed-book, closed-notes exam. The exam time is 70 minutes.**
- **Write down your name and student ID at the top of this page.**
- **Please write legibly. If we can't read your writing, we won't give you credit.**
- **For any question that involves calculation, you must show derivation. If you write down a number without any derivation, you will get 0.**
- **If the answer is not an integer or simple floating point number, it's ok to leave it as a fraction or keep the square root or log. For example: $1/7$ is fine, so is $\sqrt{2}$ and $\ln(3)$ -- there is no need to write down their numeric values.**
- **Do not worry about slightly misspelling or misnaming functions when you write down code snippets. Points will not be taken off for that.**
- **The last section is extra credit.**

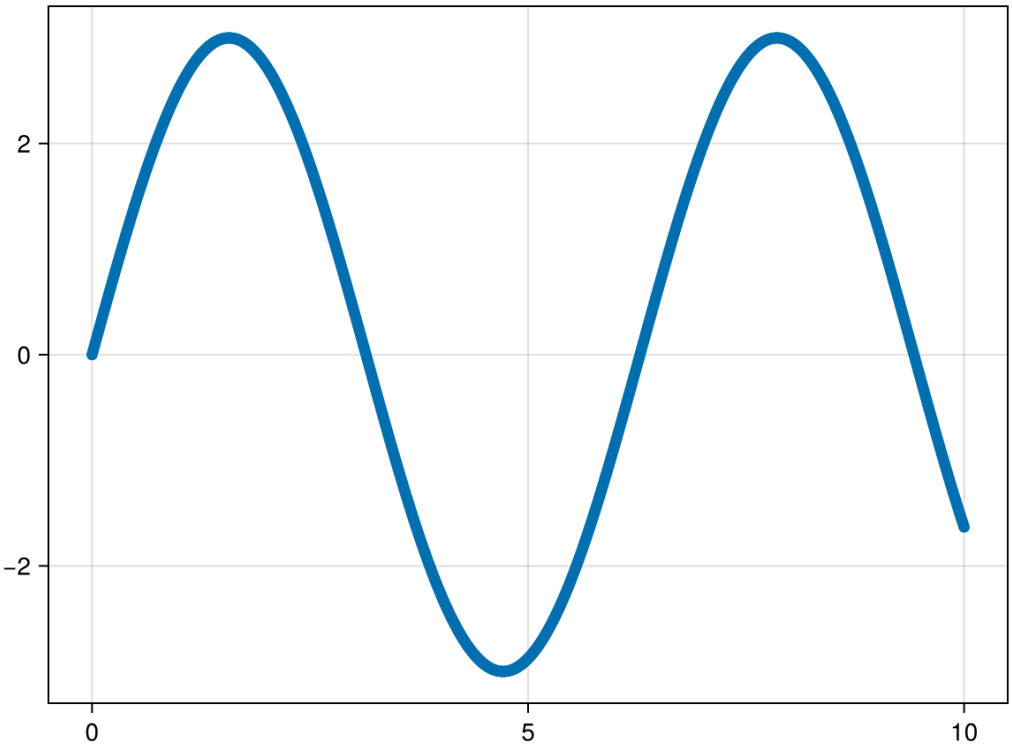
Q1. Full Bridge Rectifier [5pts]
Consider the following circuit



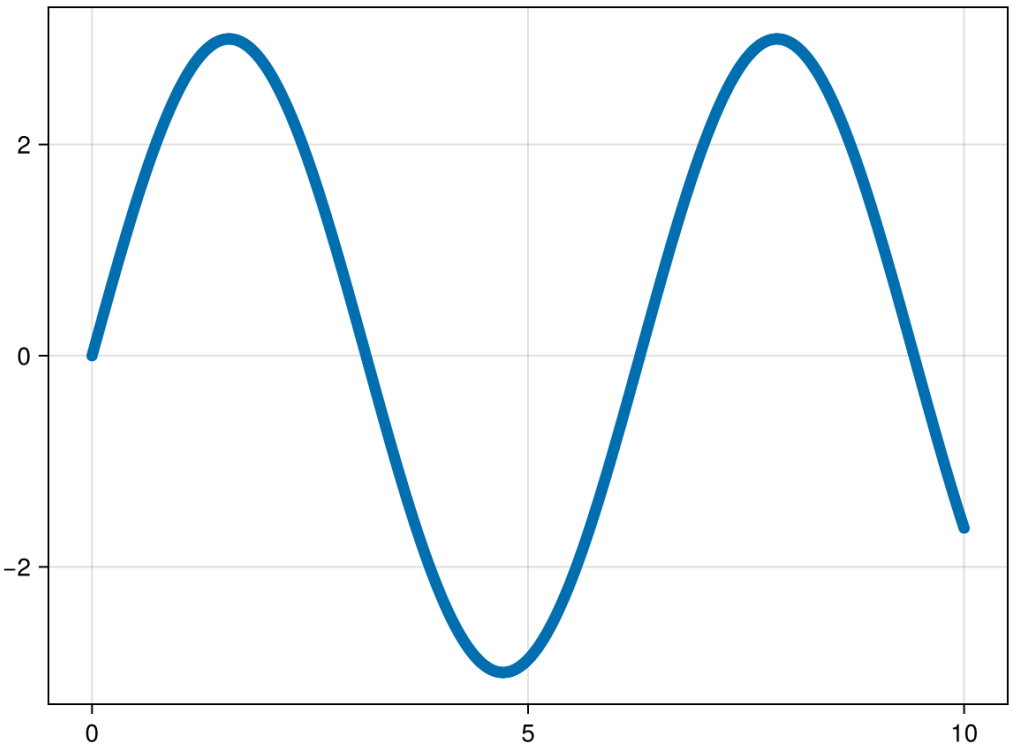
Here is a plot of the voltage difference V_a-V_b as a function of time (e.g. due to having A and B connected to an AC voltage source). On top of this plot, draw the line corresponding to V_c-V_d (e.g. imagine you are measuring it with a voltmeter while nothing else is connected there). Assume the forward voltage drop of the diodes is zero.



Q2. Full Bridge Rectifier with a real diode [3pts]
Same question as Q1, but assume the forward voltage drop of the diodes is 1V.



Q3. Incomplete Rectifier [3pts]
Same question as Q1, but assume D_3 and D_4 are deleted.



Q4. [2pts] Which transistor type requires a current limiting resistor in front of the pin that usually controls whether the transistor is switched on or off? Why is a current limiting resistor not necessary for the other type of transistor?

Q5. [6pts] Why is it unwise to drive a load like an aquarium pump directly from the pin of a microcontroller? Draw a driving circuit that works around this issue. Include the power source and microcontroller output pin in the diagram. Do not forget that pumps are heavy inductive loads. If you do not remember the exact symbol for a given component, just use a box and label the component.

Q6. [2pts] Write down a C++ function that computes the parity of the bits `b1, b2, b3, b4, b5`. It has to be a valid C++ function, but feel free to use separate `` `int` `` data types for each bit as an integer that would be having the values 0 or 1, if you are not familiar with other common C/C++ data types.

Q7. [8pts] A temperature-dependent resistor has a resistance $R = R_0 + \alpha T$ where T is the temperature. One end of that resistor is connected to a constant voltage power source V. The other end of the resistor is connected directly to a pin of a microcontroller. The pin of the microcontroller has an internal "pull-down" resistor R_{pd} which connects internally to ground, thus forming a voltage divider. Derive the expression for T as a function of the result of `m = analogRead(...)` (where m=0 corresponds to measured voltage of zero volts and m=1024 corresponds to measured voltage equal to V, the power source voltage). Your expression probably will involve all aforementioned constants and you can assume you know the values of V, R_0, α, R_{pd} in appropriate units. (ungraded bonus question): Anything particularly bad about this type of setup?

Q8. [6pts] Write the a `loop` function (as usually done in the Arduino and PlatformIO IDEs) that results in the following properties for the overall program:

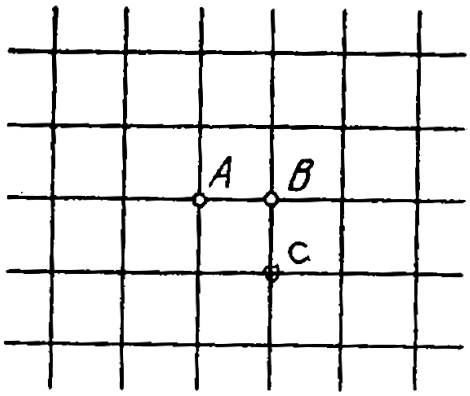
- The function `get_sensor_value()` is called once every 2 seconds;
- The function `change_fan_speed()` is called once every 10 seconds;
- No `delay` or other similar blocking functions are used.

If you need some global variables, define them as well.

EXTRA CREDIT Section. You MUST show derivations.

30 points (the hubris option)

Consider an infinite grid of wire where each link in the grid (each side of one of the small rectangles) is made of a piece of wire that has resistance R:



1. What is the resistance between points A and B?
2. What is the resistance between points A and C?

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