Problem 1: Computing Systems

A wide range of computing systems are currently in production. Consider the following devices when answering the questions below: a laptop, a digital watch, a scientific calculator, a supercomputer, and a smartphone.

(a) Sketch a curve showing computational performance of all these systems as a function of their cost. Put performance on the y-axis (arbitrary units), and cost on the x-axis (dollar estimate).

(b) Similarly, show a curve that relates computational performance to system power consumption, with performance on the y-axis (arbitrary units), and power consumption on the x-axis (watt estimate). In the case of the smartphone, ignore the power consumption of the radio.

Problem 2: Logic

Consider the circuit below. All inputs (P, Q, D0, D1, D2, and D3) must be tied to 0 or 1.

(It might help to simplify this circuit, as you would with the kind of powerful diagramming tool I do not have.)

(a) What must D0, D1, D2, D3 be such that F = P ⊕ Q?
(b) Can any arbitrary 2 input logic function of signals $P$ and $Q$ be realized using the above architecture? Explain.

**Problem 3: Logical Gates**

You work for Sldgly, a start-up in San Francisco that uses the sludge found in the Bart transit system to perform logic functions. They call this device a Sludge Gate; every Sludge Gate requires a supply and ground, has input signals $X$ and $Y$, and produces an output signal $Z$.

Here is the behavior of the Sludge Gate with a 5 V supply:

- $0 < Z < 5V$
- If $X$ and $Y$ have less than 2 V at the input for 5 microseconds or more, then $Z$ is greater than 4 V
- When either or both of $X$ and $Y$ have more than 3.5 V for at least 5 microseconds, then $Z$ is less than 1 V

The exact voltage at $Z$ is unpredictable and varies from Sludge Gate to Sludge Gate.

(a) Propose a simple topology using Sludge Gates to invert an input signal, $S$.

(b) For the inverter in (a) draw a very simple voltage transfer curve, making sure to label key voltages on both axes.

(c) What Boolean function of $X$ and $Y$ does the Sludge Gate implement?
Problem 4: Structural Verilog

Write modules using structural Verilog which implement the circuit drawn below. You will need multiple module statements to preserve the hierarchy as drawn.

Problem 5: Behavioral Verilog

For the logic circuit shown below, write the equivalent behavioral Verilog module which takes A and B as inputs, and gives X as output.