Luminosity electrical engineering take home technical interview.

The EE technical interview for The Luminosity Lab aims to cast a wide net for talented and hardworking undergrad and graduate EE students who are interested in changing the world through interdisciplinary research and development. This is a take home technical interview with open access to books, notes, and the internet. You must complete the interview questions independently and only direct questions for clarification to your hiring manager. You must attempt at least three questions (excluding bonus questions), and you are welcome to attempt as many as you'd like. This interview aims to assess both your existing technical skills as well as problem solving approach. If you are unable to fully solve any of the problems, that does not disqualify you from employment. Especially for young undergraduate students, the problem-solving approach and effort level is more important than correct solutions. You are encouraged to get outside of your comfort zone and research and attempt problems that you may be unfamiliar with. After completing the technical interview, you will meet with your hiring manager and discuss the attempted problems. You will be asked to walk through your thought process and results. You are encouraged to use as many tools at your disposal such as Python, MATLAB, Excel, etc. to assist in solving these problems.

The interview is broken down into several questions spanning the electrical engineering discipline. Even if you are unfamiliar with the topic, attempting the problem can only benefit you. Some questions are more open-ended than others and the questions are not equally challenging. This is not a test, and you will not be scored. This is an opportunity for you to communicate your work ethic and problem-solving abilities.

1) Write a function in the C programming language that uses multiply, divide, addition, and subtraction operations to synthesize approximations for sin, cos, and the exponential functions at least withing error, $\varepsilon=0.001$. Each function should take a single floating-point argument and return a single floating point number. The argument units for sin and cos can be either degrees or radians.

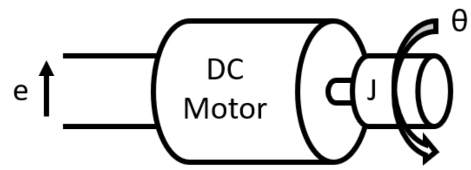
2) Using the multiply, divide, and addition operators, write a (1D) Fast Fourier Transform (FFT) function in C. Ensure that the fft size can be adjusted.

3) Write a (1D) convolution function in C which convolves two arrays of floats. Implement a hann, hamming, or blackman-harris window with the convolution function.

4) Design a discrete PID controller for the following plant: (you may use MATLAB, Simulink, Python, etc. to design and test your solution)

$$H(s) = \frac{3.86(s + 0.744)}{s(s\text{-}1)}$$

5) Create a state-space model of a simple DC motor with inertia load. Parameter values are not given. Solve analytically with variables in your state-space model.



Given:

$$\tau = K_1 I_{in}$$

$$v = K_2 \omega$$

$$I_{in} = \frac{e\text{-}v}{R}$$

Parameter	**Description**
θ	Angle of motor
ω	Angular velocity of motor
e	Applied potential
R	Armature resistance
v	Internal voltage
I_{in}	Input current
J	Rotor load inertia
K_1	Torque constant
K_2	Velocity constant

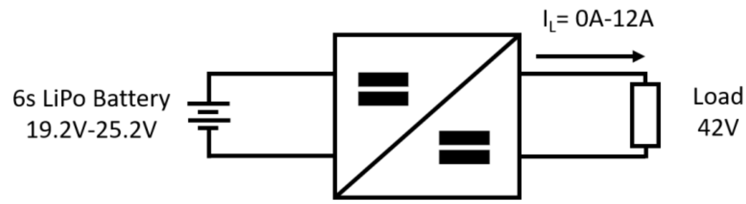
6) Design a digital band reject filter for processing an audio recording with an unwanted buzzing caused by a 60Hz florescent light (which emits a 120Hz buzzing sound). A Python or MATLAB demonstration is encouraged.

7) You are helping a colleague working on a power converter. Each switch in the MOSFET based power converter has RMS current, I_{RMS} = 30A, and R_{DSON}= 30 mΩ, and V_{RMS}= 50 V. There are four switches, all bonded to a heat sink with a thermal compound. The maximum allowable junction temperature of the switches are 100 °C and the ambient temperature is 30°C. The thermal resistance of the junction is $R_{\theta J}$ = 0.7 °C/W and the thermal bonding compound thermal resistance is $R_{\theta TC}$ = 0.34 °C/W. Taking only conduction losses into account (no switching losses considered) what is the maximum thermal resistance required for the heat sink to prevent overheating?

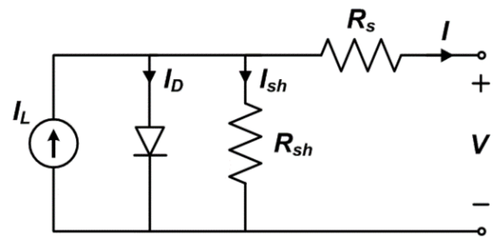
8) A remote surveillance camera system consumes 50 W of power continuously. You are tasked with specifying a solar generation and storage system to ensure that the system is powered. Assume solar panels cost \$151.30/m^2, and batteries cost \$0.40/Wh. Determine the optimal size of the solar panels, required battery storage capacity, and total cost. The solar panel efficiency is 21%. Use the solar irradiance data in the table below to help size the components: (hint: it is recommended that you interpolate the data)

Hour	Irradiance (W/m^2)
1	0
2	0
3	0
4	0
5	0
6	258.8190451
7	500
8	707.1067812
9	866.0254038
10	965.9258263
11	1000
12	965.9258263
13	866.0254038
14	707.1067812
15	500
16	258.8190451
17	0
18	0
19	0
20	0
21	0
22	0
23	0
24	0

9) Design a DC-DC converter that powers a 42V variable load with a 6s LiPo battery. The battery voltage is 25.2V when fully charged and can be discharged down to 19.2V. The output voltage should remain constant with a variable load current between 0A and 12A. Output voltage ripple figure should be between 5-10% of nominal output voltage. The more detailed the design, the better.



10) Model a photovoltaic (PV) solar panel using a single diode equivalent circuit model (https://pvpmc.sandia.gov/modeling-steps/2-dc-module-iv/diode-equivalent-circuit-models/) in Python. Plot the IV characteristics of a single PV panel in various irradiance conditions. Write a maximum power point tracking (MPPT) algorithm to solve for the optimal operating voltage to maximize solar power harvesting. (The MPPT algorithm does not have knowledge of the irradiance on the panel or ambient temperature, only the current at a given operating voltage)



PV Model Parameter	Parameter Value
Photon Current (I_{ph})	8 A
Reverse Saturation Current (I_O)	200 nA
Shunt Resistance (R_{sh})	200 Ω
Series Resistance (R_s)	10 mΩ
Diode Ideality Factor (n)	1.25
Number of cells (N_s)	60

11) Design a matching network to match a 50 Ω source impedance with a 75 Ω load. The operating frequency ranges from 900 MHz to 1100 MHz.

12) Write a Python script that modulates a digital message into IQ (in-phase and quadrature) signals using your choice of digital modulation scheme (BPSK, QPSK, QAM, ASK, etc.). Plot the signal IQ constellation and time domain modulated signal. (Bonus if you can write a demodulator from IQ samples back to digital data for an incoherently sampled signal with added Gaussian white noise.)

13) An antenna on a lunar rover needs to transmit signals back to Earth. The antenna should have high gain and directionality and be relatively physically compact. The antenna must operate in S-band. Make recommendations to the team with possible antenna design solutions.

14) Design an analog band rejection filter to suppress spurs in your signal that occur between 10.01 GHz and 10.15 GHz.

15) Design an analog front-end filter for a 40 MS/s analog to digital converter (ADC) which samples signals between DC-400 kHz.

BONUS QUESTIONS:

1) What is your favorite programming language and why?
2) What are your hobbies outside of academics?
3) What is your favorite movie?
4) What are your favorite science or engineering related YouTube channels?
5) What is your favorite circuit simulator and why? (LTSpice, PLECS, QUCS, ADS, etc.)