**WRITTEN EXAM**

**Selection process number:** 23-AGR-BCAB-EA-STB-33512

**Position title:** Research Assistant – Novel imaging technology & bioinformatics research and development (EG-04)

**Department:** Agriculture and Agri-Food Canada

**Location:** Lethbridge, Alberta

**Instructions:**

This written exam will be assessing the following merit criteria:

* Ability to use scientific instruments and to apply and adapt scientific methodologies.
* Ability to make observations, record data and perform calculations accurately.
* Ability to use programming in C or C++ and Python.
* Problem Solving

Candidates must pass each merit criteria to pass the exam. The exam can be completed by hand (please label all questions) and scanned in, or typed in the space provided under each question in this document. Candidates can use more space by answering on separate pages (if hand written) or making more space in the Word document. Succinct answers are expected; point form answers are acceptable as long as they are clear.

**You will have 1 week to complete and submit the exam by email. You have to return your completed exam to** [**jennifer.robinson5@agr.gc.ca**](mailto:jennifer.robinson5@agr.gc.ca) **by 9 am Mountain Daylight Time (MDT)/11 am Eastern Daylight Time (EDT)/8 am Pacific Daylight Time (PDT) on Tuesday, October 31, 2023.**

If, before or during the testing session, you experience physical or psychological indisposition of sufficient severity to interfere with your test performance, it is your responsibility to inform Jennifer Robinson ([jennifer.robinson5@agr.gc.ca](mailto:jennifer.robinson5@agr.gc.ca )) that you cannot undertake or continue the test. If you choose to undertake or continue the test despite your indisposition, you must accept the test results and the accompanying retest restrictions.

It is not permitted to consult anyone while undertaking this exam. If you need a scientific resource that you are unable to access due to a paywall, contact [jennifer.robinson5@agr.gc.ca](mailto:jennifer.robinson5@agr.gc.ca), and we will do our best to get you access in a reasonable time period. Any delay you might encounter when making such a request is accounted for in the allotted time period and no extensions will be issued.

Candidates who participate in any fraudulent activity in regard to this electronically administered exam or in regard to any other element of this selection process will be eliminated. In addition, the Department will inform the Public Service Commission of any instance where a candidate is suspected of engaging in fraudulent or misleading practices in regard to this selection process.

This exam is confidential and relates to the assessment process. Therefore, we request that you do not disclose any of the contents. If you have any questions, you can contact Jennifer Robinson at [jennifer.robinson5@agr.gc.ca](mailto:jennifer.robinson5@agr.gc.ca).

I agree to maintain the confidentiality of this assessment process:

\_\_\_Alex D’Angelo\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_30/10/2023\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Name Date

**Ability to use programming in C or C++ and Python, problem solving, ability to make observations, record data and perform calculations accurately**

* **Take home Exam 1 (Estimated time to complete is less than 2 hours if you have experience in C or C++, and Python):** 
  1. In the package you were shipped, you’ll find an Arduino and USB2 cable, 2x RGB LED (one is a spare), 2x photoresistors (one is a spare), a breadboard, 10x jumper cables, resistors, and some opaque tape that is stuck to your breadboard. Your task is to capture data from the photoresistor while cycling through various RGB light intensities.
     + Set up your Arduino and breadboard: Point your LED and photoresistor at one another so they are close/touching and wrap the tape around them so little/no outside light is hitting the photoresistor and they are secured together for the entire experiment. You can then bend the leads so they can be positioned as you want in the breadboard. Set up your breadboard so your LED and photoresistor are connected to the Arduino via jumpers. *Hints:*
       - *The 680 ohm resistor is for use in the photoresistor circuit*
       - *The 220 ohm resistor is for use with the red LED circuit*
       - *The 330 ohm resistors are for use with the blue and green LED circuits*
       - *The photoresistor is to be run on a 5 V circuit.*
       - *LED information: Forward voltage: R ~2.4V, G ~3.4V, B ~3.4V; forward current: ~20mA; common cathode.*
     + Write a program in the Arduino IDE so that you can incrementally change the light intensity of each RGB LED lead from 0 to 255 in 5 unit increments. Capture a photoresistor data point at each increment indicating the LED lead (e.g. “R”), the intensity value (e.g. “100”), and the photoresistor datapoint (e.g. “405”). If you are capable of directly logging the data as a .csv file, please do (*e.g*. using PuTTY), otherwise manually create a .csv dataset. Following the above examples, the .csv file could have line items structured like “R, 100, 405;”.
     + Save your Arduino code, your dataset, and one or more photos of your hardware setup to submit with the rest of your exam answers

See attached files: photosensor.ino, data.csv and hardware setup pictures

* 1. Using the output data of Step 3 (above), showcase your ability to program with python to process and analyze data. If you were unable to achieve a complete dataset (a), use the “fakedataset.csv” file attached in the “Take Home Exam” email.
     + Write a python script that enables you to do the following:
       - Determine the lowest R, G, and B LED intensity values that result in the maximum photoresistor value change. For example, you may achieve photoresistor signal saturation at a lower than maximum R, G, or B intensity.

print(calc\_max\_change(red)) # Return (intensity value, p resistor value)

Unclassified / Non classifié

print(calc\_max\_change(green))

print(calc\_max\_change(blue)) R: 5 registers a 56 photoresistor value change,

G: 40 registers a 63 change

B: 50 registers a 64 change

Determine the minimum R, G, and B LED intensity values that register a photoresistor signal change. For example, all RBG signals may not result in a photoresistor +1 signal at intensity change 0 to 1.

I need a bit more clarification for this but I’ll assume the first positive incremental change in the photo data is sought.

R: 20 G: 15 B: 10

* + - * Plot the photoresistor readouts against the RGB intensities.

See attached plot

* + - * Plot the photoresistor readouts at intensity value 150 for R, G, and B against their peak wavelengths, substituting R= 635 nm, G= 515 nm, and B = 470 nm.

See attached plot

* + - * Based on your data/plot above, estimate the peak sensitivity of the photoresistor. You may attempt to interpolate the peak value using some sort of curve fitting. You may assume the photoresistor is responsive to light only between 300 nm-900 nm.

In this case we measure responsivity (photoresistor value / light power (~ to wavelength)). Calculate slope of linear relationship:

I found sensitivity is 2.601374570446738 photoresistor units per nm of light energy

**Ability to use scientific instruments and to apply and adapt scientific methodologies & Problem solving**

* + **Take Home Exam Question 2**:

1. You need to obtain fractions of molecules from plants. The class of molecules you are looking to obtain interact with visible light (400-700 nm). Seek out one or more methods from the literature and propose a strategy that could be implemented.
2. Describe the fundamental principles that underly your strategy.
3. Email your response to [jennifer.robinson5@agr.gc.ca](mailto:jennifer.robinson5@agr.gc.ca).

1. You may carry out a spectrophotometry experiment on the collected sample using a spectrophotometer to analyze how the molecules interact with visible light. A spectrophotometer is a scientific instrument which allows the user to input an organic sample (ie. Bacteria, plants, etc.) and quantify the optical properties of the sample over a wide range of wavelengths. It consists of a light source, a collimator, a monochromator, a wavelength selector, a cuvette for sample solution, a photoelectric detector, and a digital display.

My proposed strategy: Investigate the properties of the sample molecules at the atomic and bulk levels by using a spectrophotometer to determine how visible light interacts it. In general, the device consists of two separate devices: a spectrometer and photometer. The spectrometer produces, disperses and measures light. A photometer measures the intensity of light using photoelectric effect.

The experimental steps should be as follows:

* Place the sample molecules into the spectrophotometer
* Set the device to various wavelengths in the visible spectrum
* Illuminate the sample with each wavelength
* Measure the absorbance and transmittance of the sample

2. The first important principle in the operation of this experiment is photoelectric effect. Photons in a light beam have a characteristic energy associated with them which is proportional to the frequency of the light beam. This is called the photon energy and can be written as:

E = hc/λ

where E is the photon energy, λ is the photon’s wavelength, c is the speed of light and h is the Planck constant. Thus, by calculating the energy, we can describe the sample to favour more or less energetic absorbance and/or transmittance.

Atomic level properties affect how light passes through materials depending on its transmittance or absorption properties, while a material’s surface properties affect how light is reflected by the surface. Spectrophotometric techniques interrogate these material properties by illuminating a material with light and then detecting the light’s response to the material. You need a spectrometer to produce a variety of wavelengths because different compounds absorb best at different wavelengths. The amount of photons passing through the sample into the detector is dependent on the cuvette (container) length and the concentration of molecules in the sample. By first determining the intensity of light before the sample (Io), we can measure the intensity of light after the sample (It) and calculate the transmittance (T):

T=It/Io

Transmittance (T) is then related to the sample’s absorbance (A) by the expression:

A = −log(T) or simply −log(It/Io)

Thus, by calculating the absorbance, we can make conclusions on the sample’s ability to absorb photons in the visible spectrum. We can also determine the concentration of molecules in the sample by the Beer-Lambert Law:

c=A/ϵl

where A is absorbance (no units), ϵ is the molar extinction coefficient (or absorption coefficient), l is the path length through the sample, and c is the concentration.

Therefore, by performing these measurements on the sample and few calculations using these principles, we can gauge the samples interaction characteristics with visible light.

References

Atkins, Peter and Julio de Paula. Physical Chemistry for the Life Sciences. New York: Oxford University Press, 2006.

Chang, Raymond. Physical Chemistry for the Biosciences. USA: University Science Books, 2005.

Gore, Michael. Spectrophotometry & Spectrofluorimetry. New York: Oxford University Press, 2000.

Price, Nicholas and Dwek, Raymond and Wormald, Mark. Principles and Problems in Physical Chemistry for Biochemists. R. G. Ratcliffe. New York: Oxford University Press, 1997.

Irwin H. Segel, Biochemical Calculations (How to Solve Mathematical Problems in General Biochemistry), 2nd edition, John Wiley & Sons, 1975

http://www.nist.gov/pml/div685/grp03/spectrophotometry.cfm