Begin your response to **QUESTION 1** on this page.

PHYSICS 2

SECTION II

Time—1 hour and 30 minutes

4 Questions

Directions: Questions 1 and 4 are short free-response questions that require about 20 minutes each to answer and are worth 10 points each. Questions 2 and 3 are long free-response questions that require about 25 minutes each to answer and are worth 12 points each. Show your work for each part in the space provided after that part.

1. (10 points, suggested time 20 minutes)

In each trial of a photoelectric experiment, a scientist uses a device to shine light of a single frequency on two different metals, 1 and 2. The device can emit light with frequency f_A, f_B, or f_C. Each frequency of light is used to test both metals.

The scientist determines the minimum de Broglie wavelength λ_e of the electrons ejected from the metal in each trial of the experiment. The following table summarizes the results of the experiment. For each trial, the scientist analyzes only the electrons with the minimum de Broglie wavelength.

Trial	Frequency of Light	Metal Tested	λ_e ($\times 10^{-10}$ m)
1	f_A	Metal 1	6.9
2	f_A	Metal 2	9.4
3	f_B	Metal 1	No electrons ejected
4	f_B	Metal 2	No electrons ejected
5	f_C	Metal 1	5.3
6	f_C	Metal 2	6.3

GO ON TO THE NEXT PAGE.

Continue your response to **QUESTION 1** on this page.

(a) In a coherent, paragraph-length response, **indicate** which frequency, f_A, f_B, or f_C, is greatest and which frequency is least. **Justify** your answer using physics principles.

(b) **Calculate** the maximum kinetic energy of the electrons ejected from Metal 1 in Trial 1. Assume that the momentum p of an ejected electron can be described by the classical definition $p = mv$.

(c) **Indicate** whether the work function of Metal 1 is greater than, less than, or equal to the work function of Metal 2. **Justify** your answer by referring to the table of results.

GO ON TO THE NEXT PAGE.

Question 1: Paragraph-Length Response — 10 points

(a)

For indicating that f_B is least and f_C is greatest — **1 point**

For correctly relating the frequency of a photon to the energy of the photon — **1 point**

For indicating that the kinetic energy or speed of an ejected electron is inversely related to the de Broglie wavelength of the electron — **1 point**

For indicating **one** of the following: — **1 point**

- That a greater photon energy or frequency results in a greater kinetic energy for an ejected electron
- That the lowest photon energy or frequency is below the work function or threshold frequency which results in no ejected electron

For a logical, relevant, and internally consistent argument that addresses the required argument or question asked, and follows the guidelines described in the published requirements for the paragraph-length response — **1 point**

Example Response

An electron will be ejected if the incident photon has an energy greater than the work function of the metal. Because no electrons were ejected using f_B, the corresponding photon energy, and, therefore, frequency must be the least. A photon with greater frequency will result in an ejected electron with more kinetic energy; the kinetic energy of an electron is inversely related to the de Broglie wavelength of the electron. Because the de Broglie wavelength of electrons ejected by light of frequency f_A is greater than those ejected by light of frequency f_C, f_A must be less than f_C. Therefore, f_C is the greatest.

Total for part (a) 5 points

(c)	For indicating that the work function of Metal 1 is less than the work function of Metal 2 with an attempt at a relevant justification	**1 point**
	For indicating at least **two** of the following: • The correct relationship between the work function and the difference between hf and $K_{\max}$ • The frequency or energy of the incident photons is the same • The de Broglie wavelength is inversely related to the energy of the ejected electrons	**1 point**
	Example Response *The work function of Metal 1 is less than the work function of Metal 2. When light of the same frequency is incident on both metals, the electron ejected by Metal 1 has a smaller de Broglie wavelength than that of Metal 2, so an electron ejected from Metal 1 has more kinetic energy. The work function is the difference between the photon energy and the maximum kinetic energy. Since the photon energy is the same but the maximum kinetic energy is larger for Metal 1, the difference between the energies, and thus the work function, is smaller for Metal 1.*	
	Total for part (c)	**2 points**
	Total for question 1	**10 points**