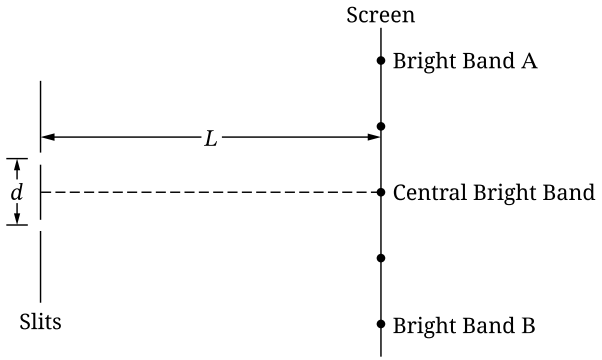
Question 4

4. Two narrow slits are a distance d apart. A screen is a distance L from the midpoint of the slits, where $L \gg d$. When a laser emits monochromatic light toward the slits, a pattern of narrow bright and dark bands is observed on the screen. The centers of bright bands A and B are indicated. Three additional bright bands, including the central bright band, are observed on the screen between bands A and B, as shown.



Note: Figure not drawn to scale.

A student claims that the distance between the center of Band A and the center of the central bright band is smaller when using a laser that emits violet light than when using a laser that emits red light.

A. Indicate whether the student's claim is correct or incorrect. Without manipulating equations, **justify** your answer by referencing the difference in path length traveled by the light from each slit to the center of Band A.

B. Derive an expression for the distance between the centers of bands A and B when light of frequency f is emitted toward the slits. Express your answer in terms of d, L, f, and physical constants, as appropriate. Begin your derivation by writing a fundamental physics principle or an equation from the reference information.

C. Indicate whether the expression you derived in part B is or is not consistent with your answer from part A. Briefly **justify** your answer.

STOP

END OF EXAM

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

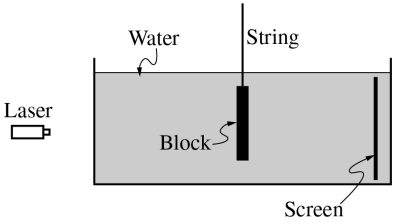
PHYSICS 2

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.



. (10 points, suggested time 20 minutes)

Students are investigating electromagnetic wave phenomena in transparent media. They use a string to support a stationary thin, rectangular block of mass m_b, volume V_b, and density ρ_b. The block has two narrow slits in its center and is submerged in a glass tank containing water with density ρ_w, as shown above.

GO ON TO THE NEXT PAGE.

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

(a)

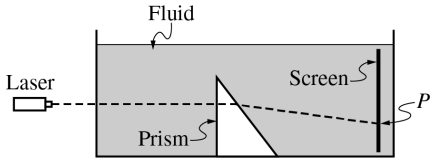
i. On the dot below, which represents the block, draw and label the forces that are exerted on the block. Each force must be represented by a distinct arrow starting on, and pointing away from, the dot.

ii. Derive an expression for the force exerted on the block by the string in terms of the given quantities and physical constants, as appropriate.

GO ON TO THE NEXT PAGE.

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

(b) A monochromatic laser beam is incident perpendicular to the wall of the tank. The beam passes through the slits in the block. An interference pattern is formed on the screen inside the tank. The water is then replaced with a clear fluid with a greater index of refraction than that of water. In a coherent, paragraph-length response, describe how the greater index of refraction of the new fluid affects the interference pattern. Explain your reasoning in terms of speed, frequency, and wavelength of the light.



(c) The block is replaced by a triangular prism, as shown above. The path of the beam is indicated by the dotted line, and the beam reaches the screen at point P. The fluid is then removed from the tank, and the prism is surrounded by air. Predict whether the beam will reach the side of the tank above point P, at point P, or below point P when the prism is surrounded by air. Support your answer using physics principles.

GO ON TO THE NEXT PAGE.