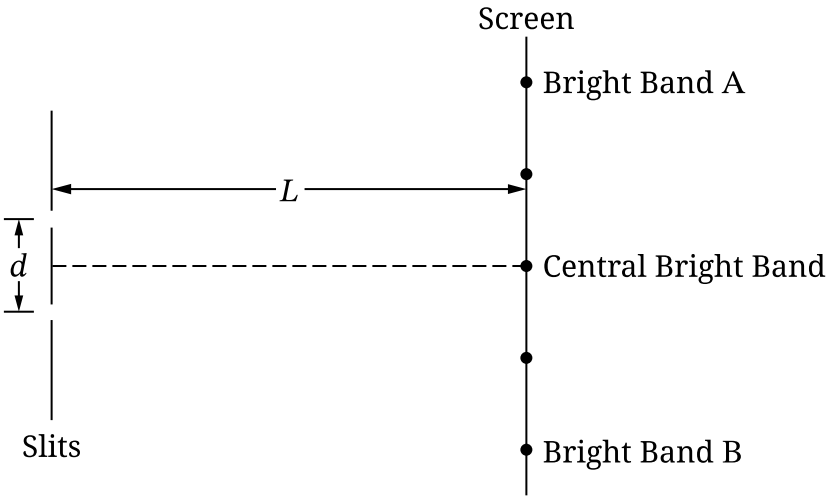
Question 4

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

Question 4: Qualitative Quantitative Translation (QQT) — 8 points

A

For indicating **one** of the following: **Point A1**

- The claim is correct if a justification is not provided.
- An indication about the claim that is consistent with the justification provided.

For a correct comparison of **one** of the following: **Point A2**

- The wavelength of violet light is shorter than the wavelength of red light.
- The frequency of violet light is greater than the frequency of red light.

For indicating that a shorter wavelength corresponds to a shorter path length difference, resulting in a shorter distance between the center of Band A and the center of the central bright band **Point A3**

Example Response

The claim is correct. The wavelength of violet light is shorter than that of red light. This shorter wavelength leads to a shorter path length difference for violet light as compared to red light. This corresponds to a shorter distance between Band A and the central band.

B

For a multistep derivation that includes $d\left(\frac{y_{\max}}{L}\right) \approx m\lambda$, $d\sin\theta = m\lambda$, $\Delta D = m\lambda$, $\Delta D = d\sin\theta$, $\Delta D \approx d\left(\frac{y_{\max}}{L}\right)$, $d\sin\theta \approx d\left(\frac{y_{\max}}{L}\right)$, $\sin\theta \approx \left(\frac{y_{\max}}{L}\right)$, $\tan\theta \approx \left(\frac{y_{\max}}{L}\right)$, $\theta \approx \left(\frac{y_{\max}}{L}\right)$, an equation that is equivalent to one of the equations listed, or a relevant equation **Point B1**

For a substitution of $\frac{c}{f}$ for λ **Point B2**

For correctly relating $y_{\max}$ to the orders of bands A and B **Point B3**

(e.g., $2\left(y_{\max,2} - y_{\max,0}\right) = 2\left(\frac{(2)cL}{fd}\right)$)

Scoring Note: A correct, isolated, final expression earns points B2 and B3.