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.

Example Response

$$d\left(\frac{y_{\max}}{L}\right) \approx m\lambda$$

$$\lambda = \frac{c}{f}$$

$$d\left(\frac{y_{\max}}{L}\right) = m\frac{c}{f}$$

$$y_{\max} = \frac{mcL}{fd}$$

$$\Delta y = 2\left(y_{\max,\,2} - y_{\max,\,0}\right)$$

$$\Delta y = 2\left(\frac{(2)cL}{fd}\right)$$

$$\Delta y = \frac{4cL}{fd}$$

C	For correctly indicating that the expression derived in part B is or is not consistent with the answer provided in part A	**Point C1**
	For a justification that includes the consistent functional dependence between the spacing between bright bands on the screen and the frequency or wavelength of light	**Point C2**

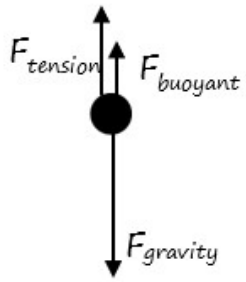
Example Response

My derivation in part B is consistent with my answer in part A. Violet light has a greater frequency than red light. Because $\Delta y = \frac{4cL}{fd}$*, a greater frequency for violet light results in a shorter distance between bright bands.*

Question 1: Short Answer Paragraph Argument — 10 points

(a)(i) For correctly drawing and labeling the gravitational, buoyant, and tension forces with no extraneous forces — **1 point**

Example Response



(a)(ii) For an application of Newton's laws that is correct or consistent with the diagram in part (a)(i) and indicates zero net force — **1 point**

For a correct substitution of the buoyant force into a solution that is consistent with the previous equation — **1 point**

Scoring Note: A correct answer with no supporting work earns this point.

Example Response

$\Sigma \vec{F} = m\vec{a}$

$F_T + F_B - F_g = 0$

$F_T + F_B = F_g$

$F_T = F_g - F_B$

$F_T = m_b g - \rho_w V_b g$

Total for part (a) 3 points

(b) For correctly relating the speed of the light in the new medium to the index of refraction — **1 point**

For indicating that the frequency does not change — **1 point**

For a correct relationship between speed and wavelength — **1 point**

For a correct relationship between wavelength and fringe separation — **1 point**

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

Example Response

The speed of light in the new fluid is less than the speed of light in water because the fluid has a greater index of refraction. This means that the wavelength of the light in the beam will be smaller because the frequency does not change. Since the wavelength is smaller, the angular separation of the bright fringes will decrease, as described by the equation $m\lambda = d\sin\theta$.

Total for part (b) 5 points

(c) For explicitly indicating that the amount of refraction at the fluid-prism interface depends on the ratio of the indices of refraction of the materials **1 point**

Scoring Note: Basing the explanation on the difference in refractive indices is acceptable.

For correctly relating a larger angle of refraction to the beam hitting the screen below point *P* **1 point**

Example Response

The beam refracts more when the air is present because the difference between the indices of refraction between the prism and the surrounding medium is greater. So, the beam hits the screen below point P.

Total for part (c) 2 points

Total for question 1 10 points