# 20S-PHYSICS1C-1 Quiz 5

CHARLES ZHANG

TOTAL POINTS

**17.5 / 30**

QUESTION 1

1 5a **2.5 / 5**

- **0 pts** Correct
- **1 pts** talks about path differences due to wave reflection does not talk about phase change due to reflection.

✓ - **2.5 pts** **partly right (mentions interference of two signals for example) details are not complete**

- **4.5 pts** some attempt
- **5 pts** no attempt

QUESTION 2

2 5b **5 / 10**

- **0 pts** Correct
- **3 pts** mostly right/ d= 2d double slit is specified

✓ - **5 pts** **partially right right expression wrong distances/pi shift missing/work not shown**

- **8.5 pts** some attempt
- **10 pts** no attempt

QUESTION 3

3 5c **5 / 5**

✓ - **0 pts** **Correct**

- **2 pts** partly right - talks about refractive index change leading to lowering of maxima - no mention of how wavelength changes or phase/final answer is wrong but steps are right
- **4 pts** some attempt/wrong statements
- **5 pts** wrong

QUESTION 4

4 5d **5 / 10**

- **0 pts** Correct
- **1 pts** slight error/incomplete details

✓ - **5 pts** **partly right subtraction of two locations with fixed locations and k**

- **8 pts** some attempt
- **10 pts** no attempt

# 1CS20 QUIZ 5

**Full Name (Printed)** Charles Zhang

**Full Name (Signature)** 

**Student ID Number** 305 413 659

- The exam is open-book and open notes. You will probably do better to limit yourself to a single page of notes you prepared well in advance.
- **All work must be your own.** You are not allowed to collaborate with anyone else, you are not allowed to discuss the exam with anyone until all the exams have been submitted (after the close of the submissions window for the exam).
- You have 30 minutes to complete the exam and sufficient time to scan the exam and upload it to GradeScope. The exam *must* be uploaded to GradeScope within the time alloted (that is, by the end of the lecture hour). We will only except submissions through GradeScope and will not accept any exam submitted after the submission window closes (CAE students must contact Corbin for instructions).
- **Given the limits of GradeScope, you must fit your work for each part into the space provided.** You may work on scratch paper, but you will not be able to upload the work you do on scratch paper, so it is essential that you copy your complete solution onto the exam form for final submission. We can only consider the work you submit on your exam form.
- **For full credit the grader must be able to follow your solution from first principles to your final answer.** ***There is a valid penalty for confusing the grader.***
- It is **YOUR** responsibility to make sure the exam is scanned correctly and uploaded before the end of the submission window. The graders may refuse to grade pages that are significantly blurred, solutions to problems that are not written in the correct place, pages submitted in landscape mode and/or work that is otherwise illegible - if any of this occurs, you may not receive *any* credit for the affected parts.
- Focus on the concepts involved in the problem, the tools to be used, and the set-up. If you get these right, all that's left is algebra.
- **Have Fun!**

**The following must be signed before you submit your exam:**

**By my signature below, I hereby certify that all of the work on this exam was my own, that I did not collaborate with anyone else, nor did I discuss the exam with anyone while I was taking it.**

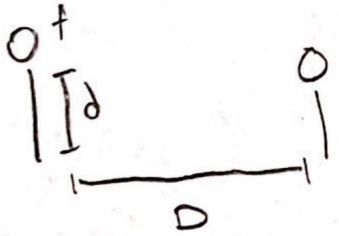
**Signature** 

26 miles across the sea, on a hilltop overlooking Santa Catalina Island, a transmitter broadcasts radio signals at a frequency $f$ from the top of a tower at an altitude $d$ above sea-level. The sky is clear and the ocean is very calm. On the other side of the channel, somewhere on the coast near Palos Verdes (a horizontal distance $D$ from the tower on Catalina), a technician is climbing up another tall tower.

At some point, rather high on the tower, the technician decides to turn on a portable receiver she's brought along. Watching the signal strength climb as she ascends the tower, she makes note of the point at which the signal from Catalina is the strongest and marks the tower.

- 5a) (5 points) Given the distance from the technician to the transmitter site doesn't change significantly as she climbs the tower, how do you account for the change in signal strength that she observes? The more correct, relevant, clear and detailed your answer is, the more points you are likely to receive.

Diffraction




As the technician approaches the location of the central max on her tower, the intensity of the signals increases. This is because most of the radio waves power is located within this central maximum.

- 5b) (10 points) How much further up the tower will our technician have to climb to find a point where the signal strength drops to its lowest value? ← $y_{min}$ (1st order dark fringe)

Marked at $\theta = 0°$

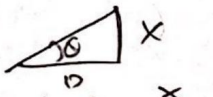
$\sin\theta = \frac{m\lambda}{a} \rightarrow m = 1$

$\sin\theta = \frac{\lambda}{a} \rightarrow \lambda = \frac{c}{f}$

$\sin\theta = \frac{c}{fa} \rightarrow$ how to get $a$?

Assume $a = 2d$ (probably wrong)

$\sin\theta = \frac{c}{2fd}$




$\tan\theta = \frac{x}{D}$

$\theta$ small $\rightarrow \tan\theta \approx \sin\theta$

$\sin\theta = \frac{x}{D}$

$\frac{c}{2fd} = \frac{x}{D}$

$$x = \frac{cD}{2fd}$$

$\Delta\theta_{path} = \frac{2\pi n}{\lambda}$

$n\uparrow = \Delta\theta_{path}\uparrow$ ✓ wrong

- 5c) (5 points) As the morning warms up, water begins to evaporate and a vapor forms over the surface of the ocean. As our technician descends the tower, will the point at which she observes maximum signal strength be above the mark she made on the way up or below it? Explain.

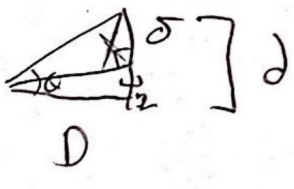
$\lambda_n = \frac{\lambda}{n}$ → wavelength goes down

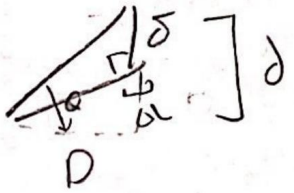
$\sin\alpha = \frac{m\lambda}{a}$ → $\lambda\downarrow = \theta\downarrow$

~~First intuition~~ → signal location doesn't change → clearly wrong based on 5d

Since the water vapor in the air means the waves are traveling through a larger refractive index, the effective wavelength of the frequency decreases. As a result, the max will be lower, as the angle decreases when the wavelength decreases. This effect is demonstrated by the separation of white light in a diffraction experiment.

- 5d) (10 points) If the distance between the original mark made by the technician and the new point at which she observes maximum signal strength is given by $\delta$, how much phase difference did the water vapor introduce into the relevant path?




→ originally central max at same height!

$\Delta\theta_{path} = |\Delta k|L$ → Find $\Delta L$

$\Delta L = \delta \sin\theta$

$\theta = \tan\theta = \frac{d}{D}$ $\quad n = \frac{c}{v}$

$\Delta k = 1 - n_{water}$

$\Delta L = \delta \sin\left(\frac{d}{D}\right)$

$\Delta\theta_{path} = |\Delta k|L = \frac{2\pi(1-n_{water})}{\lambda}\delta\sin\left(\frac{d}{D}\right)$

$$\Delta\theta_{path} = \frac{2\pi(1-n_{water})c}{f}\delta\sin\left(\frac{d}{D}\right)$$