20S-PHYSICS1C-1 Quiz 3

CHARLES ZHANG

TOTAL POINTS

25 / 30

QUESTION 1

1 3a 10 / 10

✓ **- 0 pts** **Correct**

- 2 pts mistakes - (area missing the 4) or 4piD2 instead of 1/4

- 3 pts partial credit (force components not quite right) area for the laser pressure is not right. basic idea is right.

- 8 pts some attempt. wrong concept

- 10 pts wrong

QUESTION 2

2 3b 10 / 10

✓ **- 0 pts** **Correct/part a was wrong but part b had the right steps**

- 3 pts incomplete description

- 5 pts partial credit/rms instead of max/wrong pressure equation

- 8 pts some attempt/ too many errors

- 10 pts wrong

QUESTION 3

3 3c 5 / 10

- 0 pts Correct

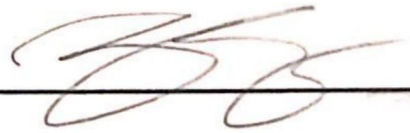
✓ **- 5 pts** **missing area component, area mentioned is wrong, wrong due to part a being wrong,p expression is wrong, missing a double due to perfect reflection**

- 8 pts some attempt/too many errors

- 10 pts wrong

1CS20 QUIZ 3

Full Name (Printed) Charles Zhang

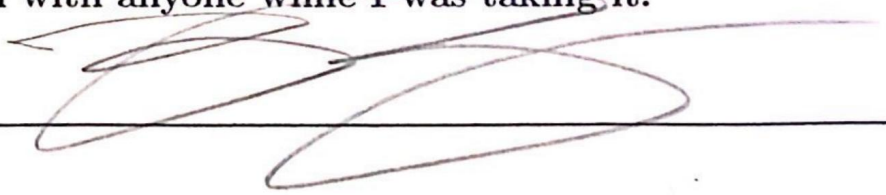
Full Name (Signature) 

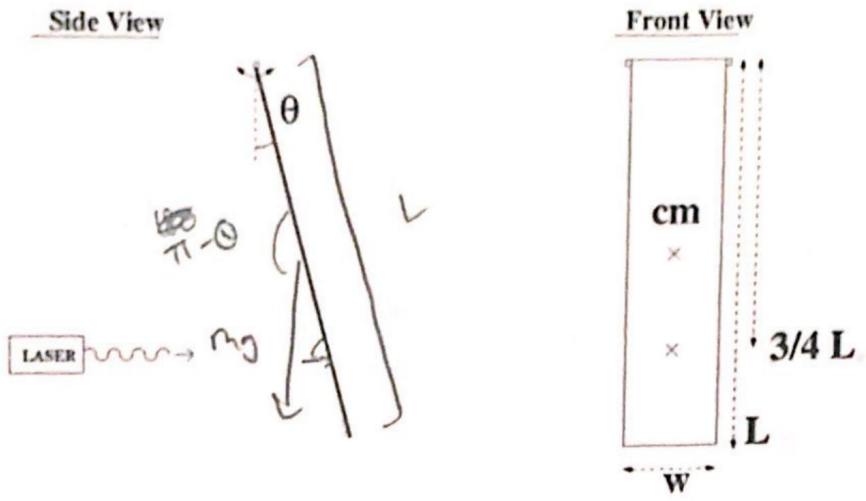
Student ID Number 305-413-659

- 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 <u>YOUR</u> 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 



A large, thin, uniform, highly reflective sheet of length L, width w (where $w < L$). and mass m is hung vertically from a horizontal peg (as shown). When the beam (of diameter $D \ll w$) from a powerful green laser is shown on a spot directly between the center of mass and the lower edge of the sheet, the sheet is deflected by a *very small* angle θ ($\sin\theta \approx \tan\theta \approx \theta$).

- 3a) (10 points) How much pressure is exerted on the sheet by the laser?

$P = \frac{F}{A}$

$A = \frac{1}{4}\pi D^2$

$P = \frac{4F}{\pi D^2}$

$\Sigma\tau = 0$

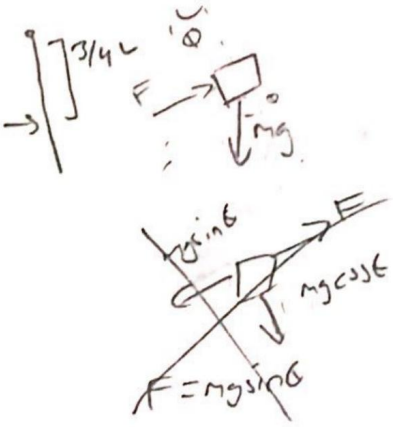
$\Sigma\tau = mg(\frac{1}{2}L)\sin(\pi-\theta) - F(\frac{3}{4}L)\sin(\frac{\pi}{2}-\theta)$

$mg(\frac{1}{2}L)\sin(\pi-\theta) = F(\frac{3}{4}L)\cos\theta$

$\frac{1}{2}mg\sin\theta = \frac{3}{4}F\cos\theta$

$F = \frac{2}{3}mg\tan\theta$

$$\boxed{P = \frac{8}{3}\frac{mg\theta}{\pi D^2}}$$



- 3b) (10 points) Find the *amplitudes* of the electric and magnetic fields associated with the light emitted by the laser.

P varies w/ theta → $P = P_{avg}$ → Assumption?

highly reflective → $P = \frac{2I}{c}$

$I = \frac{P_c}{2} = I_{avg}$

$I_{avg} = \frac{E_{max}B_{max}}{2\mu_0} = \frac{1}{2}\varepsilon_0 c E_{max}^2$

$\frac{P_c}{2} = \frac{1}{2}\varepsilon_0 c E_{max}^2$

$P = \varepsilon_0 E_{max}^2$

$\frac{8}{3}\frac{mg\tan\theta}{\pi D^2} = \varepsilon_0 E_{max}^2$

$$\boxed{E_{max} = \sqrt{\frac{8}{3}\frac{mg\theta}{\varepsilon_0\pi D^2}}}$$

$E_{max} = cB_{max}$

$B_{max} = \frac{E_{max}}{c}$

$$\boxed{B_{max} = \frac{\sqrt{\frac{8}{3}\frac{mg\theta}{\varepsilon_0\pi D^2}}}{c}}$$

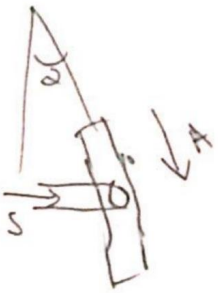
- **3c) (10 points)** What is the power output of the laser?

$$\text{Power} = \int \vec{S} \cdot d\vec{A}$$

$$S_{avg} = \frac{E_{max} B_{max}}{2\mu_0} = \frac{1}{2}\varepsilon_0 c E_{max}^2$$

$$S_{avg} = \frac{1}{2}\varepsilon_0 c \left(\frac{\frac{2}{3} mg\tan\theta}{\varepsilon_0 \pi D^2}\right)$$

$$S_{avg} = \frac{4}{3}\left(\frac{mgc\tan\theta}{\varepsilon_0 \pi D^2}\right)$$



$$\text{Power} = SA\cos\theta$$

$$\text{Power} = \frac{4}{3}\left(\frac{mgc\tan\theta}{\varepsilon_0 \pi D^2}\right)\left(\frac{1}{4}\pi D^2\right)\cos\left(\frac{\pi}{2} - \theta\right)$$

$$\cos\left(x - \frac{\pi}{2}\right) = \sin\theta$$

$$\cos(-\theta) = \cos\theta$$

$$\cos\left(\frac{\pi}{2} - x\right) = \sin\theta$$

$$\text{Power} = \frac{1}{3}\left(\frac{mgc\tan\theta}{\varepsilon_0}\right)\sin\theta$$

$$P_{avg} = \frac{mgc\tan^2\theta}{3\varepsilon_0}$$