19F-PHYSICS1C-4 Final

[redacted]

TOTAL POINTS

96 / 100

QUESTION 1

Question 1 12 pts

1.1 1a 4 / 4

✓ + **4 pts** **Full credit: $$ \frac{input}{output} = \frac{2}{1}$$**

+ **2 pts** Half credit: $$ \frac{input}{output} = \frac{1}{2}$$

+ **0 pts** No credit: $$ \frac{input}{output} \neq \frac{1}{2}$$ or $$\frac{2}{1}$$

- **3 pts** No work or justification

1.2 1b 4 / 4

✓ + **4 pts** **Full credit: diffraction for vers. A/C-B), for vers. B/D-C)**

+ **0 pts** No credit: any other option marked; multiple options marked; ambiguous what is marked; nothing is marked

1.3 1c 4 / 4

✓ + **4 pts** **Full credit: 1) "spacing between slits" 2) "slit width" (or what have you not in phrasing); one correct and other left blank,**

+ **2 pts** Both assigned to either one i.e. 1) "spacing between slits" 2) "slit width"; one correct but other blank

+ **0 pts** No credit: 2) "spacing between slits" 1) "slit width" (or what have you not in phrasing); both blank

QUESTION 2

2 Question 2 12 / 12

✓ + **12 pts** **Correct**

+ **3 pts** Correct Units

+ **2 pts** I_0/2 for unpolarized light passing through a filter (first filter does not also throw in a factor cos^2(30))

+ **2 pts** Cosine

+ **2 pts** Trig function Squared per filter

+ **3 pts** 2 Angles Correct (measured with respect to the current polarization of the light)

+ **2 pts** 1 Angle Correct (measured with respect to the current polarization of the light) (exclusive with Rubric item 6)

+ **1 pts** The correct SI unit is W/m^2, but if you put lumens or candela, which are easy to get confused, you get a point back. (mutually exclusive with rubric item 2)

QUESTION 3

Question 3 14 pts

3.1 3a 4 / 4

✓ + **4 pts** **Correct**

+ **2 pts** Mirror Equation

+ **1 pts** s' < 0 because it is a virtual image

+ **1 pts** Specify the correct side

+ **0 pts** Click here to replace this description.

3.2 3b 4 / 4

✓ + **4 pts** **Correct**

+ **2 pts** Magnification equation

+ **0 pts** Click here to replace this description.

3.3 3c 6 / 6

✓ + **6 pts** **Click here to replace this description.**

+ **2 pts** Correct for ray 1

+ **2 pts** Correct for ray 2

+ **2 pts** Correct for ray 3

+ **0 pts** Click here to replace this description.

QUESTION 4

4 Question 4 **12 / 12**

✓ + **12 pts** **Correct**

+ **11 pts** all correct, but didn't make it clear that B point into the page

+ **11 pts** all correct but didn't convert cm to m; final result off by some power of 10

+ **10 pts** all correct, except not realizing B2 = 2 * B1 (saying something like B2 = B1, etc.)

+ **10 pts** all correct, except subtracting B as though the B direction is determined solely by the current direction (should appy right hand rule)

1 good

2 Nice

QUESTION 5

5 Question 5 **12 / 12**

✓ + **12 pts** **Correct**

+ **3 pts** Get magnetic field due to straight wire OK

+ **2 pts** Understand flux as surface integral B.dA, not line integral or something else

+ **3 pts** Correctly write down the integral for magnetic flux (B is not constant over the entire area)

+ **2 pts** Evaluate the above integral, note that integral 1/r = ln b/a

+ **1 pts** unit of flux: Weber (Wb) or T.m^2. I forgive if you write W.

+ **1 pts** numerical result correct

+ **0 pts** no credit

QUESTION 6

Question 6 12 pts

6.1 6a **3 / 3**

✓ + **3 pts** **Correct**

+ **1 pts** Units

+ **1 pts** chi=omega*L (omega=2*pi*f)

+ **1 pts** Number/Method (award points if EFT from an error in chi but otherwise correct approach)

+ **0 pts** Incorrect

6.2 6b **2 / 3**

+ **3 pts** Correct

+ **1 pts** Used correct formula for Z (or tan(phi))

✓ + **1 pts** **Power Factor Formula**

✓ + **1 pts** **Result/Method**

+ **0 pts** Incorrect

6.3 6c **3 / 3**

+ **3 pts** Correct

+ **1 pts** Units

+ **1 pts** Irms = Vrms/Z with correct Z calculation (up to EFT)

+ **1 pts** Includes Correct Power Factor usage up to EFT

✓ + **3 pts** **Correct with Error Followed Through**

+ **0 pts** Incorrect

6.4 6d **2 / 3**

+ **3 pts** Correct

✓ + **2 pts** **Leads**

+ **1 pts** Number

+ **3 pts** Correct with EFT

+ **0 pts** incorrect

QUESTION 7

Question 7 14 pts

7.1 7a **10 / 10**

✓ + **10 pts** **Correct :)**

+ **9 pts** Correct except for sign in Lorentz Tranformation

+ **0 pts** See solutions.

+ **7 pts** Should have used x2'=0. Mavis is not moving in S'. Otherwise would have found correct answer.

+ **5 pts** Time transformation correct but not distance.

+ **3 pts** Gamma is correct. But the main part of the problem: identification of the events and using them in the Lorentz Transformation is not.

+ **5 pts** Distance transformation correct but not time transformation

+ **5 pts** Distance transformation would have been correct if correct time had been used. Time transformation incorrect.

7.2 7b **2 / 4**

+ **4 pts** Correct

✓ + **2 pts** **Correct wavelength but wrong type**

+ **2 pts** Correct type but wrong wavelength

+ **0 pts** See Solutions

+ **2 pts** Wrong wavelength but correct type if that had been the answer.

+ **3 pts** Wavelength should be longer that what Mavis emitted since Mavis is receding. Used reciprocal but otherwise correct and put correct type given wrong answer.

+ **4 pts** Some minor math errors but otherwise correct.

QUESTION 8

Question 8 12 pts

8.1 8a **6 / 6**

✓ + **6 pts** **Correct**

+ **2 pts** t = 2d

+ **2 pts** (m + 1/2)

+ **2 pts** For smallest: m = 0

+ **0 pts** Click here to replace this description.

8.2 8b **6 / 6**

✓ + **6 pts** **Correct**

+ **2 pts** round trip 600 nm

+ **2 pts** every distance from 0 to 48 um is used left to right

+ **2 pts** miscellaneous

+ **0 pts** Click here to replace this description.

Name: [redacted]

University ID: [redacted]

FINAL EXAM
Version A
Physics 1C, Prof. David Saltzberg
Dec. 11, 2019

Time: 3 hours. Closed Notes. Closed Book. No internet. Two 3”×5” sheets. Calculators are allowed. Show your work. If a problem is confusing or ambiguous, notify the professor. Clarifications will be written on the blackboard. Check the board.

$\sqrt{2} = 1.4$: $(1/\sqrt{2}) = 0.7$: $e=2.7$

ln(2)=0.7 ln(3)=1.1 ln(4)=1.4 ln(5)=1.6
ln(6)=1.8 ln(7)=1.9 ln(8)=2.1 ln(9)=2.2 ln(10)=2.3

Problem	Points
1	/12
2	/12
3	/14
4	/12
5	/12
6	/12
7	/14
8	/12
TOTAL	**/100**

1) Short Answers:

a) (4 pt) You are traveling in Europe. You brought a transformer that converts a European voltage (V_{rms}) from 240V to 120V so you can plug in your American electric hair-drier. What is the ratio of number of windings on the input to the output of the transformer? [Careful: make sure your ratio is for input over output].

$$\frac{V_2}{V_1} = \frac{N_2}{N_1} \qquad \frac{120V}{240V} = \frac{N_2}{N_1} \leftarrow \frac{1}{2}$$

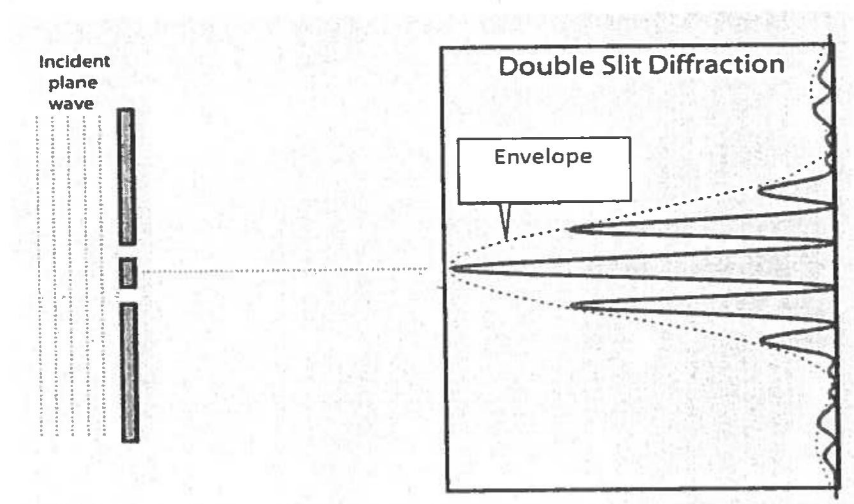
$$\frac{N_{in}}{N_{out}} = \boxed{2}$$

b) (4 pt) Which is not an essential part of making rainbows as we see them?

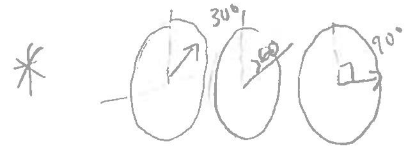
A) dispersion
B) diffraction
C) refraction
D) reflection

c) (4 pts) A screen with two slits makes the following intensity pattern. The slits on the first screen can be described by the "slit width" and by the "spacing between the slits." Specify which of these is responsible for

1) the spacing between largest intensity peaks in the diagram below spacing between the slits
2) the envelope (shown as the dashed line) of the intensity pattern. slit width



2) (12 pts) Unpolarized light with intensity of 32.0 (in SI units) passes through a polarizing filter with a polarizing angle 30° from the ~~horizontal.~~ vertical The light then passes through a similar filter with the angle 60° from the vertical. It goes through one more with an angle 90° from the vertical. What is the intensity after passing through all the filters. [Give your answer with appropriate SI units for intensity]



① $\frac{32\,J}{s\,m^2}$ goes through first $I \to \frac{I_0}{2} = \frac{32\,J}{sm^2}\cdot\frac{1}{2} = \frac{16\,J}{sm^2}$

② $\frac{16\,J}{sm^2}$ goes through second $I = I_0\cos^2\emptyset = I_0\cos^2(30) =$

$16\cos^2(30) = 12\frac{J}{sms}$

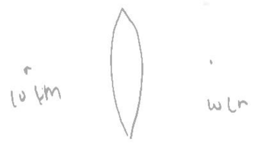
③ $\frac{12\,J}{sm^2}$ goes through third $I = I_0\cos^2\emptyset = I_0\cos^2(30) = \frac{9\,J}{sm^2}$

$I = \frac{9\,J}{s\,m^2}$

3) A converging lens with focal length f=10.0 cm forms a virtual image 6.0 mm tall that is 15.0 cm from the lens.

a) (4 pts) What is the position of the object? (Specify a numerical value and whether it is on the same or opposite side of the lens from the image.)

virtual image so $s' = -15$ cm



$$\frac{1}{s} + \frac{1}{s'} = \frac{1}{f}$$

$$\frac{1}{s} + \frac{1}{-15} = \frac{1}{10}$$

$s = 6$ cm on the same side of lens as image

b) (4 pts) What is the size of the object?

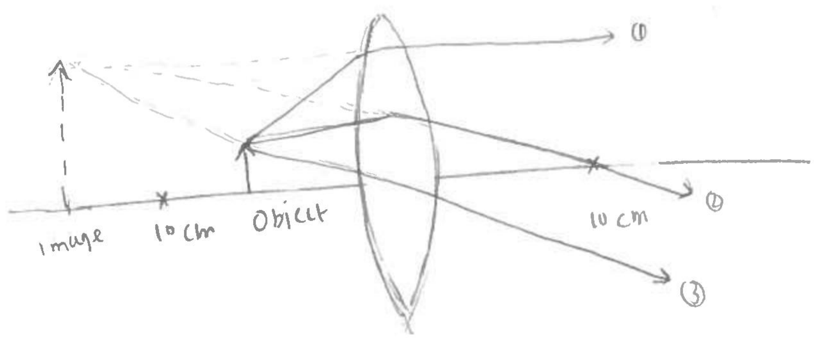
$$\frac{-s'}{s} = \frac{-(-15)}{6} = 2.5$$

$$\frac{6.0\text{ mm}}{x} = 2.5$$

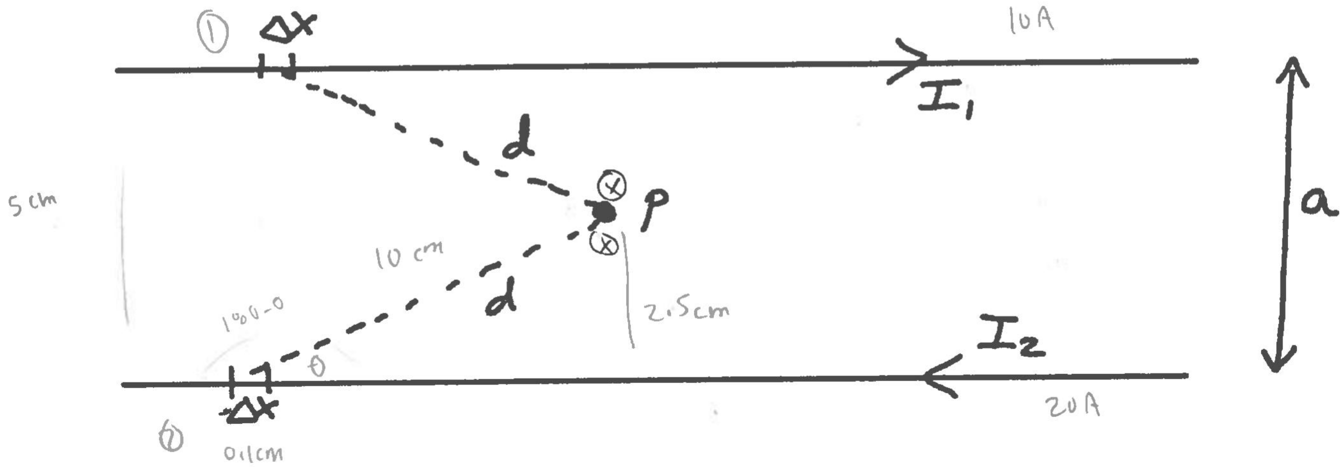
$x = 2.4$ mm

Name: [redacted]

c) (6 pts) Draw a principle-ray diagram with 3 principle rays



4) (12 pts) Two parallel wires are a distance a=5.0 cm apart and carry currents I_1=10.0 A and I_2=20.0 A in opposite directions. Point P is halfway between the two wires. Find the magnetic field from the two segments shown that are at the same position along each wire, with lengths Δx=0.1 cm. Each are d=10.0 cm from point P as shown. [extra blank page follows]



[For simplicity, you may assume Δx is small compared to all other lengths in the problem and so do not worry about the angle and distance to P changing slightly over the 0.1 cm.]

Both are into the page so add

From 1: $B = \frac{\mu_0}{4\pi}\frac{I\,dl \times r}{r^2} \rightarrow \frac{\mu_0}{4\pi}\frac{I_1 \Delta x \sin\theta}{d^2} \rightarrow \frac{\mu_0}{4\pi}\frac{I_1 \Delta x \frac{2.5}{10}}{d^2}$

$= \frac{4\pi \times 10^{-7}}{4\pi}\frac{(10)(0.001\,m)(2.5)}{10(.1^2)} = 2.5 \times 10^{-8}\ T$

From 2: $B = \frac{\mu_0}{4\pi}\frac{I\,dl \times r}{r^2} \rightarrow \frac{\mu_0}{4\pi}\frac{I_2 \Delta x \sin\theta}{d^2} \rightarrow \frac{\mu_0}{4\pi}\frac{I_2 \Delta x \left(\frac{2.5}{10}\right)}{d^2}$

$\frac{4\pi \times 10^{-7}}{4\pi}\frac{(20)(0.001\,m)(2.5)}{10(.1^2)} = 5 \times 10^{-8}\ T$

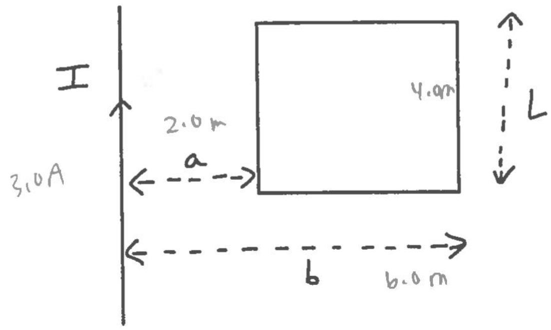
B_{total} @ P: $\boxed{7.5 \times 10^{-8}\ T}$ into the page

Name: [redacted]

[extra page for problem 4]

Name: [redacted]

5) (12 pts) The current in an infinite, straight wire on the left is I=3.0 A. The size and placement of a rectangular loop on the right is given by a=2.0 m, b=6.0 m, and L=4.0m as shown below. What is the magnitude of the magnetic flux through the loop? [Your answer should have units.] [Extra space on next page.]



$\Phi_B = B A \cos\theta \leftarrow \vec{B}$ and $\vec{A}$ are //

$$\Phi_B = \int_a^b \frac{\mu_0 I L\, dr}{2\pi r}$$

$$\frac{\mu_0 I L}{2\pi} \int_a^b \frac{1}{r}\, dr$$

$$\frac{\mu_0 I L}{2\pi} \ln r \Big|_a^b$$

$$\Phi_B = \frac{\mu_0 I L}{2\pi} \ln\left(\frac{b}{a}\right)$$

$$|\Phi_B| = \frac{(4\pi \times 10^{-7})(3.0 A)(4.0 m)}{2\pi} \ln\left(\frac{6.0 m}{2.0 m}\right)$$

$$|\Phi_B| = 2.64 \times 10^{-6}\ \text{Wb}$$

[Extra space for problem 5]

6) *[This problem probably requires your calculator.]* A large coil of wire is connected to a 400 Hz power supply. (These are common in the aircraft industry.) The coil has a resistance of 400 Ω and at this frequency has a reactance of 300 Ω.

a) (3 pts) What is the inductance of the coil [with units]?

$\omega = 2\pi(400) = 800\pi \frac{rad}{sec}$

$X_L = \omega L \; ; \; L = \frac{X_L}{\omega}$

$\frac{300\,\Omega}{800\pi \frac{rad}{sec}} = .119\,H$

b) (3 pts) The product ($V_{rms} \times I_{rms}$) has units of Watts but is not the average power P_{av} used by the circuit averaged over long times. (So often it is written as Volt-Amperes instead of Watts.) What is the ratio of P_{av} to ($V_{rms} \times I_{rms}$)?

$\frac{P_{AV}}{V_{rms} I_{rms}} = \frac{I_{rms} V_{rms} \cos\phi}{V_{rms} I_{rms}}$

$\frac{P_{AV}}{V_{rms} \times I_{rms}} = \cos\phi = \frac{400\,\Omega}{700\,\Omega}$

$\frac{P_{AV}}{V_{rms} \times I_{rms}} = .571$

c) (3 pts) What is V_{rms} of the supply if the circuit draws an average power of P_{av}=16 W?

$$P_{AV} = V_{rms} I_{rms} \cos \phi$$

$$P_{AV} = V_{rms} \left(\frac{V_{rms}}{Z}\right)\left(\frac{R}{Z}\right)$$

$$V = IZ$$

$$I = \frac{V}{Z}$$

$$P_{AV} = \frac{V_{rms}^2 R}{Z^2}$$

$$V_{rms} = \frac{P_{AV} Z^2}{R} = \sqrt{\frac{(16)(700)^2}{400}}$$

$$\boxed{V_{rms} = 140 \text{ V}}$$

d) (3 pts) By how many degrees does the phase of the voltage of the source lead or lag its current? [Specify "leads "or "lags" with a numerical answer that has absolute value ≤ 90⁰]

ELI

↑ current lags

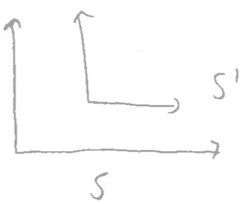
$$\cos \phi = \frac{400 \Omega}{700 \Omega}$$

$$\phi = 55.2°$$

Voltage leads current by 55.2°

7) Space Force pilot Mavis (in frame S') flies past Stanley (in frame S) at a constant speed relative to him of $v=(4/5)c$ along their x-axes. They both start their timers $t=t'=0$ at the moment Mavis passes by Stanley at a location which they both call $x=x'=0$. When Mavis's timer says 0.5 microseconds, she flashes a light that Stanley sees.

a) (10 pts) At what point in Stanley's spacetime (x,t) does she flash the light?



$t_1 = 0$ $\quad t_1' = 0$

$t_2 = ?$ $\quad t_2' = 0.5\,\mu s$

$x_1 = 0$ $\quad x_1' = 0$

$x_2 = ?$ $\quad x_2' = 0$

time dilation: $\Delta t = \gamma \Delta t'$

$\gamma(0.5\times10^{-6})$

$\Delta t = 8.33\times10^{-7}$

length: $\frac{4}{5}(3.0\times10^{8})(8.33\times10^{-7})$

$= 200\ m$

$x_2' = (\frac{4}{5}c)(0.5\,\mu s)(\frac{1\,s}{1\times10^{6}\,\mu s})$

$= 120\,m$

$t_2 = \gamma(0.5\,\mu s - \frac{u(120)}{c^2})$

$t_2 = \frac{1}{\sqrt{1-(\frac{4^2}{5}c^2)/c^2}}(0.5\,\mu s - \frac{\frac{4}{5}c(120)}{c^2})$

$t_2 = 3\times10^{-7}\,s$

$x_2 = (\frac{4}{5}c)(3\times10^{-7}\,s)$

$x_2 = 72\,m$

check with $72 = \frac{x}{\gamma} = 120$ ✓

$x = \gamma(0 + \frac{4}{5}c(0.5\times10^{-6}))$

$x = 200\,m$

Stanely sees flash (200m, 8.33×10^{-7} sec)

$t_1 = 0$ $\quad t_1' = 0$

$t_2 = ?$ $\quad t_2' = 0.5\,\mu s$

$x_1 = 0$ $\quad x_1' = 0$

$x_2 = ?$ $\quad x_2' = 0$

$t_2 = \gamma(t_2' - \frac{u x_2'}{c^2})$

$x_2 = \gamma(x_2' + u t_2')$

$t_2 = \gamma(t_2')$

$x_2 = \gamma(u(0.5\,\mu s))$

b) (4 pts) If Mavis flashed red light with wavelength 600nm, what wavelength of electromagnetic radiation would Stanley see? And what type is it (e.g., infrared, ultraviolet, visible, gamma rays, radio waves)?

traveling away so:

$$f\lambda = c$$

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

$$f = \sqrt{\frac{c-u}{c+u}}\, f_0$$

$$\frac{c}{\lambda} = \sqrt{\frac{c-u}{c+u}}\, \frac{c}{600nm}$$

$$f = \frac{1}{3}\left(\frac{c}{600nm}\right)$$

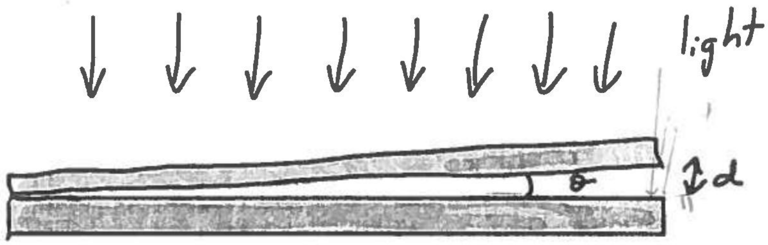
$$f = 1.66 \times 10^{14}$$

$$\boxed{\lambda = 1.8 \times 10^{-6}\ m}$$

since visible is ~ 400 nm → 700nm, this is larger wavelengths than visible

These are probably radio waves. and Stanley cannot "see" this

8) A source of light with wavelength in air of λ=600 nm illuminates two glass (n=1.5) plates as shown below. The plates are L=120 mm long and are separated on one end by a distance d. The light reflecting off of the bottom of the upper glass plate interferes with the light reflecting off the top of the lower glass plate and you can ignore any other possible sources of interference. [For simplicity, assume the light is incident on the plates normally (perpendicularly) so you do not need to worry about refraction bending the direction of the light.]



a) (6 pts) What is the smallest possible value of d so that there is a bright fringe (constructive interference) on the far right?

Since there is π phase shift on lower plate, need additional π phase shift for constructive interference. So

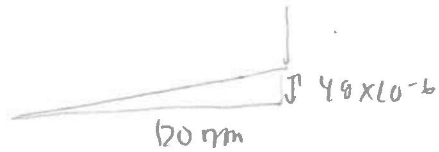
$$2d = \frac{1}{2}\frac{\lambda}{1}$$

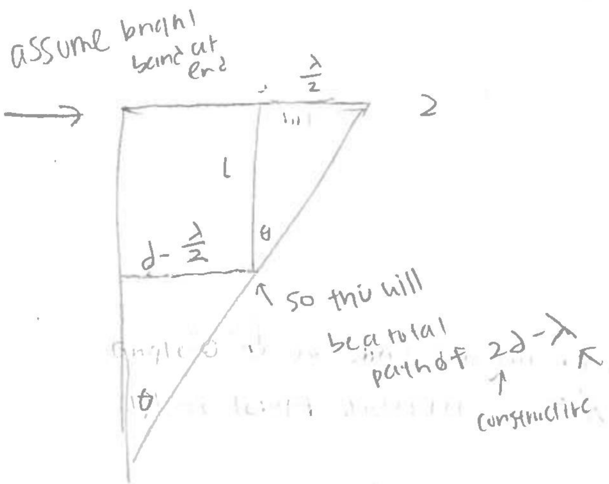
$$2d = \frac{1}{2}(600 \times 10^{-9})$$

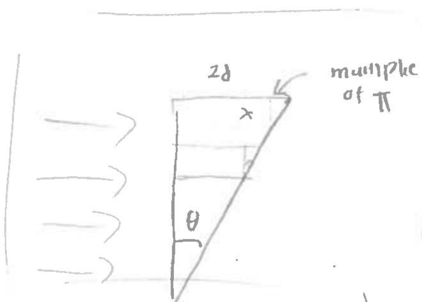
$$d = \frac{600 \times 10^{-9}}{4}$$

$$d = 1.5 \times 10^{-7}\ m$$

b) (6 pts) If d=48 μm, as if held apart by a thin human hair, how many bright lines (“fringes”) appear across the top glass plate. [For simplicity, don’t worry about ±1 in your answer because of a fringe just going past an edge.]







$\sin\theta = \frac{d}{dl}$

$2d = \sin\theta\, dl$

$\tan\theta = \frac{48 \times 10^{-6}}{120 \times 10^{-3}}$ $\theta \approx .0229°$

$\tan\theta = \frac{\frac{\lambda}{2}}{L}$

$L = \frac{\lambda}{2\left(\frac{48 \times 10^{-6}}{120 \times 10^{-3}}\right)}$

$L = 7.5 \times 10^{-4}$ ↗ spacing between

$\frac{120 \times 10^{-3}}{7.5 \times 10^{-4}} = 160$

So 160 bright bands can fit

~~$\tan\theta = \frac{d-\frac{\lambda}{2}}{L}$~~

~~$L = \frac{(48 \times 10^{-6}) - \left(\frac{600 \times 10^{-9}}{2}\right)}{\left(\frac{48 \times 10^{-6}}{120 \times 10^{-3}}\right)}$~~

~~$L = .11925$ spacing difference~~