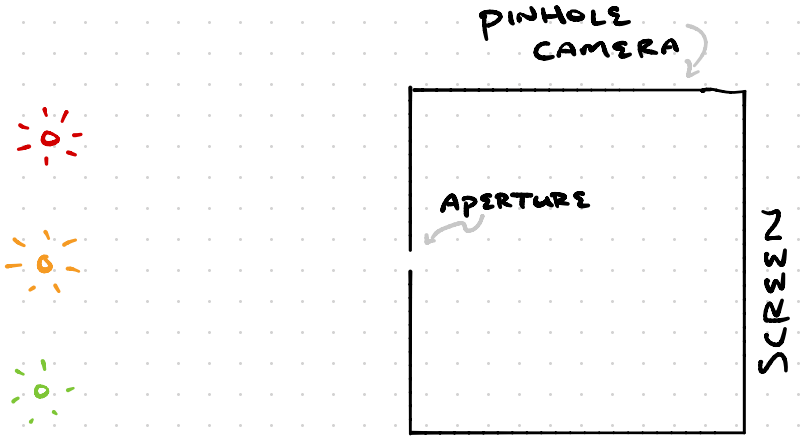
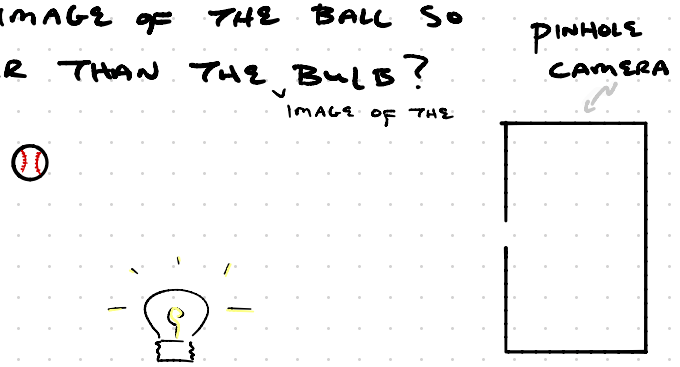
Q1 CAMERA OBSCURA

a) DRAW THE IMAGE FORMED ON THE SCREEN DUE TO THE THREE LIGHTS:

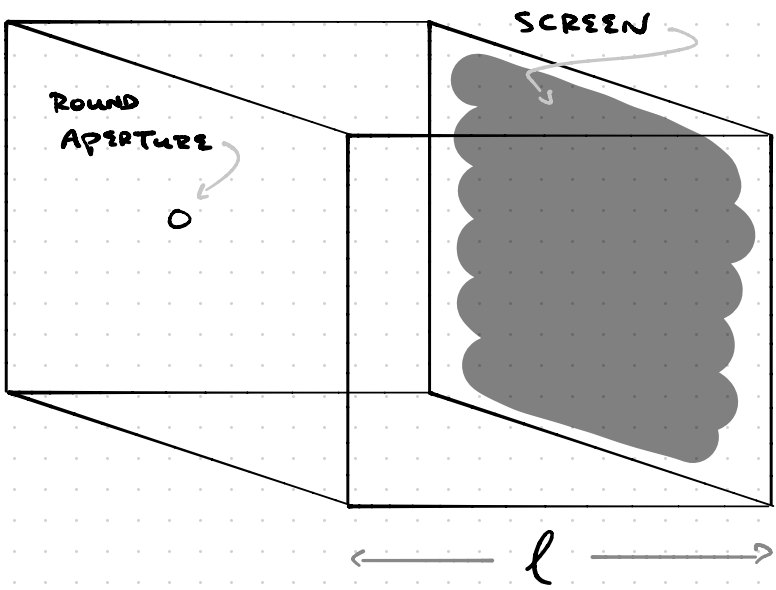


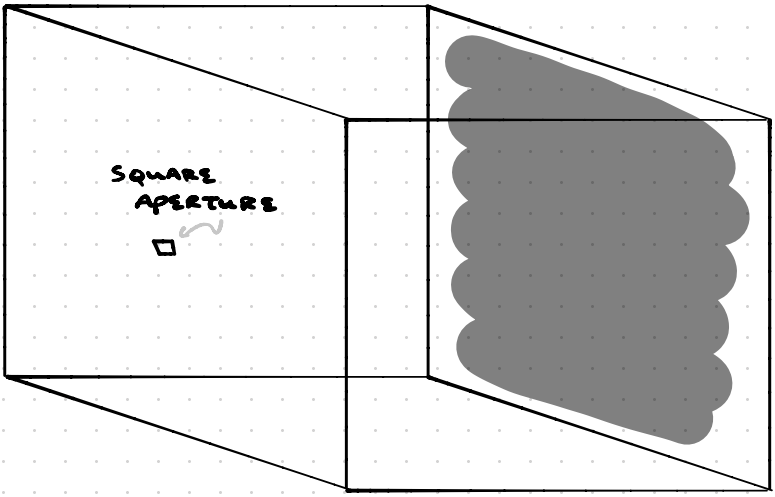
b) IF WE MAKE THE APERTURE LARGER, WE CAN LET MORE LIGHT IN BUT @ WHAT EXPENSE?

c) SHOW HOW RAYS TRAVEL TO FORM AN IMAGE OF THE BULB + BASEBALL. WHY IS THE IMAGE OF THE BALL SO MUCH DIMMER THAN THE BULB?



d)

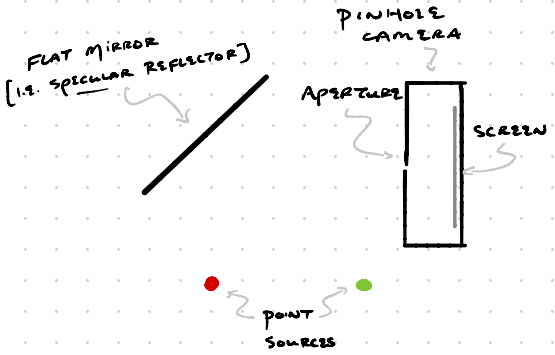




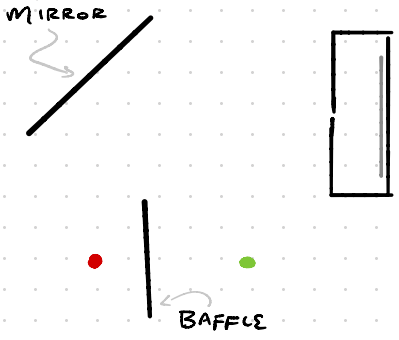
- WHY DO BOTH APERTURES FORM THE SAME IMAGE OF THE SUN?

Q2 Reflection

a) • Draw the image formed on the screen of the pinhole camera by the following arrangement:

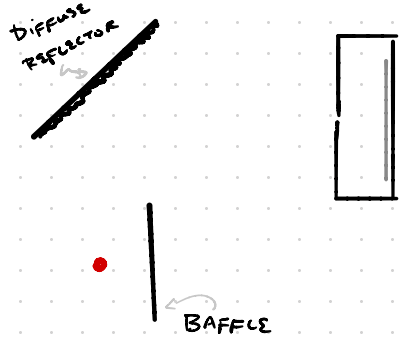


b) What if we add a "baffle" which absorbs any rays that strike it?



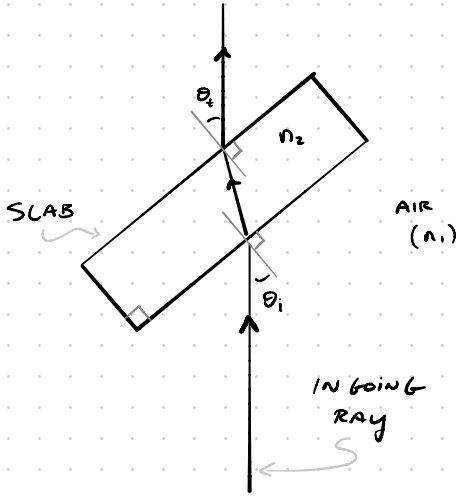
c) IF IN PART b) WE REPLACE THE CAMERA W/ YOUR EYE, THEN WHERE DO THE POINT SOURCES APPEAR TO "COME FROM"? SUPPOSE THAT YOUR EYE IS ACCURATELY MODELED AS A PINHOLE CAMERA [AS DESCRIBED IN THE NOTES].

d) WHAT IMAGE DO WE OBTAIN FOR PART b) IF WE REMOVE THE GREEN POINT SOURCE & CHANGE THE MIRROR TO A DIFFUSE REFLECTOR?



Q3 REFRACTION / DISPERSION

a) A RAY is INCIDENT ON A TRANSPARENT RECTANGULAR SLAB [E.G. GLASS OR PLASTIC] W/ AN INDEX OF REFRACTION n_2 GREATER THAN AIR'S (n_1).



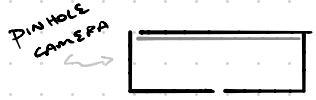
- SHOW THAT $\theta_i = \theta_t$, i.e. THAT THE SLAB SHIFTS THE RAY BUT DOES NOT DEFLECT IT.
- HOW IS THIS SHIFT DEPEND ON n_2? WHAT IF $n_2 < n_1$?

BONUS:

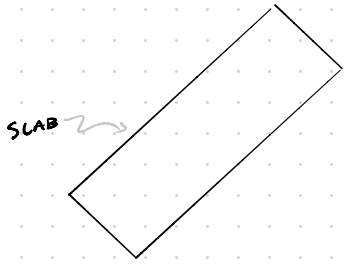
- HOW DOES THE SHIFT DEPEND ON θ_i? E.G. WHAT HAPPENS WHEN $\theta_i = 0$?

b) How does the image on the screen change by the addition of the slab between the two point sources of the pinhole camera?

Before

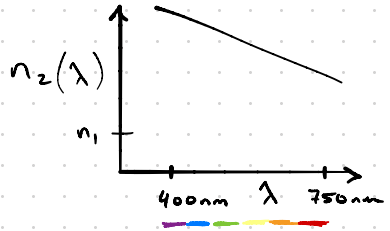


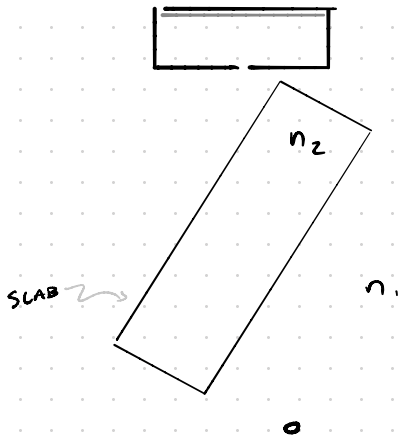
After



Hint: Draw the rays from each point source that make it to camera screen when there is no slab. Why do these rays no longer strike the camera screen when the slab is inserted?

c) DRAW THE IMAGE FORMED ON THE CAMERA SCREEN. ASSUME THE SLAB IS VERY DISPERSIVE, i.e. THE INDEX OF REFRACTION CHANGES RAPIDLY WITH WAVELENGTH:

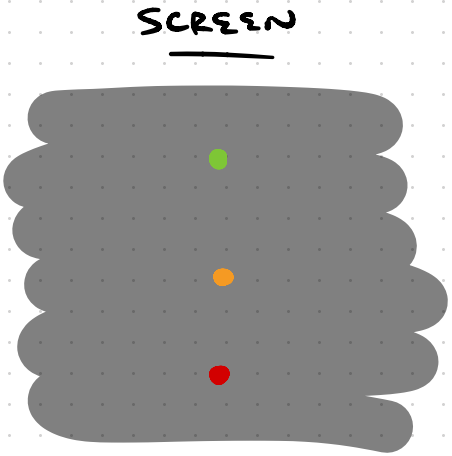


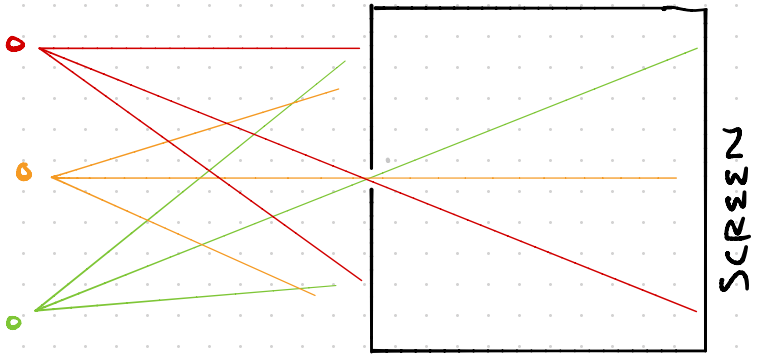


WHITE LIGHT POINT SOURCE (E.G. LIGHT BULB)

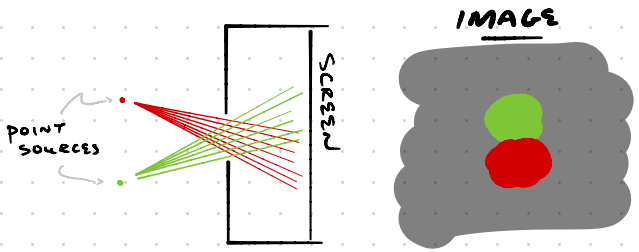
ANSWERS

Q1 a)

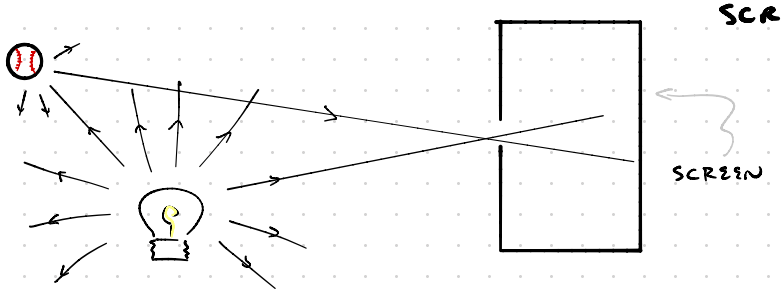




b) IF YOU ENLARGE THE APERTURE, THE IMAGE GETS BRIGHTER BUT BLURRIER



c) ONLY VERY FEW OF THE BULB'S RAYS STRIKE THE BALL, & OF THOSE, ONLY VERY FEW STRIKE THE SCREEN:



Q2

[DRAWING ONLY THE RAYS THAT MAKE IT INTO THE CAMERA]

a)

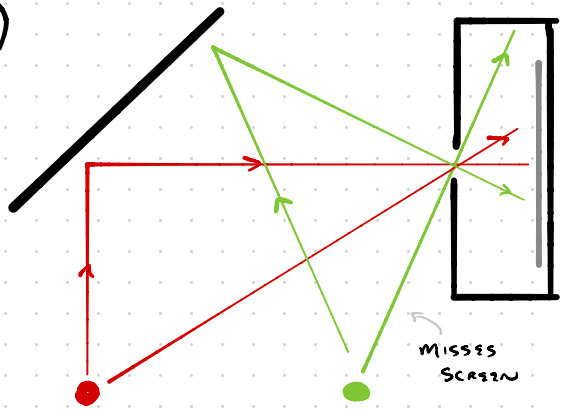
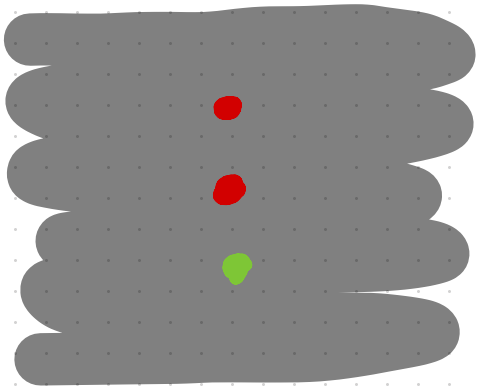


IMAGE ON SCREEN



b)

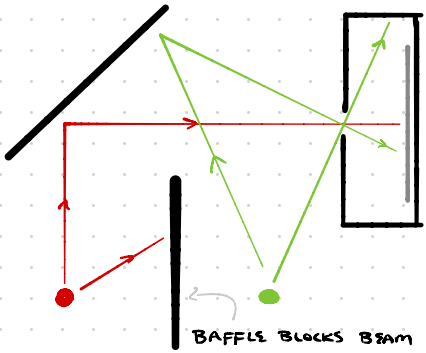
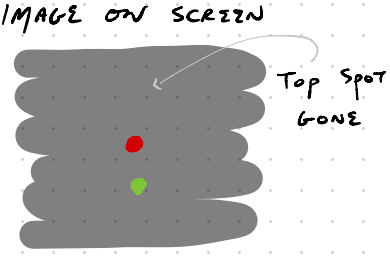
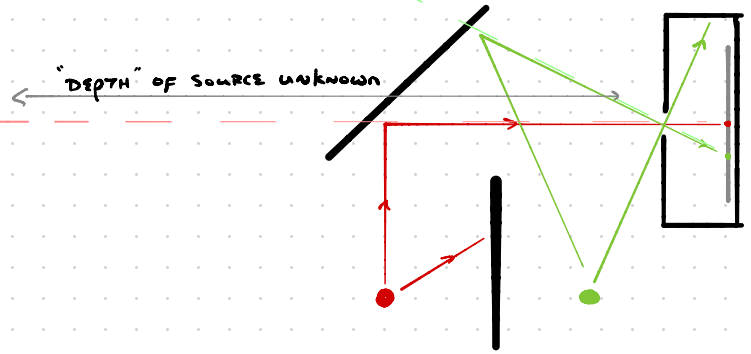


IMAGE ON SCREEN



c)

: LINES OF APPARENT ORIGIN



- PINHOLE CAMERA CANNOT "MEASURE" DEPTH. A SPOT ON THE SCREEN "APPEARS" TO COME FROM SOMEWHERE ALONG THE LINE JOINING THE CAMERA APERTURE TO THE SPOT. NOTE IN THIS CASE THE POINT SOURCES DO NOT LIE ALONG THE LINES OF THEIR "APPARENT" ORIGIN.

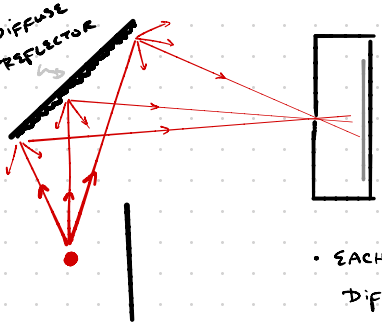
So TWO CONCLUSIONS:

PROJECTION: • IMAGES DO NOT CONTAIN THE FULL INFORMATION OF THE IMAGED SURROUNDINGS [DEPTH INFO LOST]

IMAGE ≠ OBJECT: • RADIATING SOURCES DO NOT ALWAYS LIE ALONG THE LINE THEY APPEAR TO LIE ON [MIRRORS / LENSES CAN DEFLECT RAYS SO THAT THEY APPEAR TO ORIGINATE ELSEWHERE.

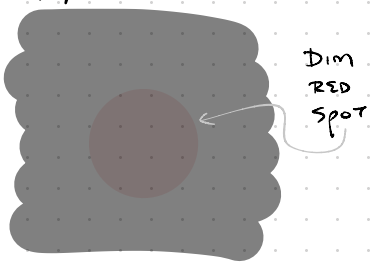
(MIRRORS: REFLECTION; LENSES: REFRACTION)

d)



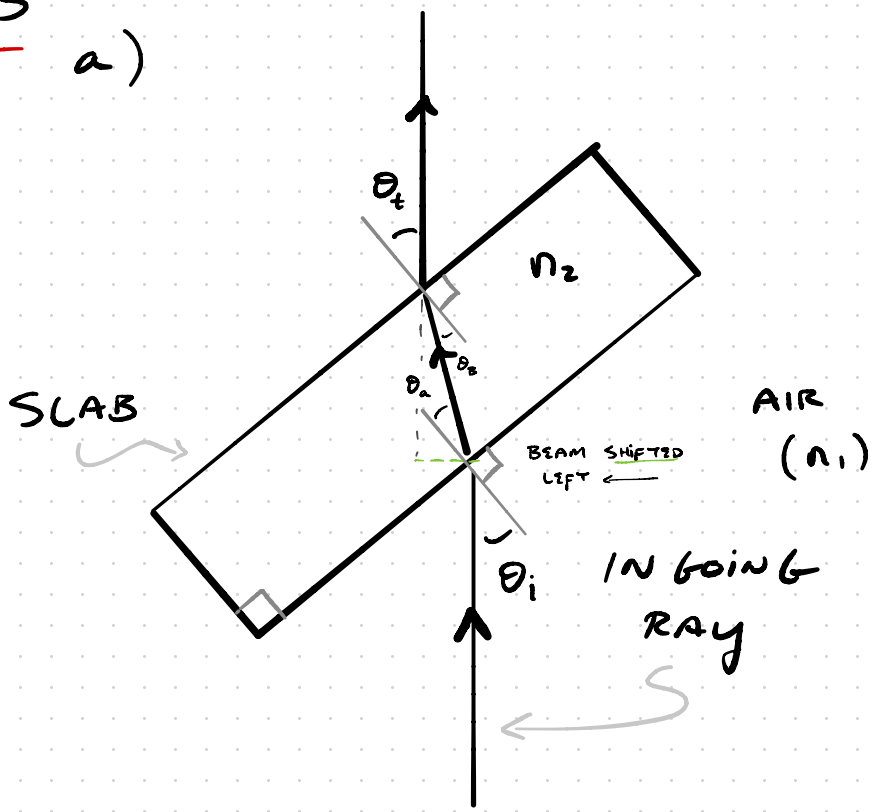
• EACH POINT ON DIFFUSE REFLECTOR SCATTERS LIGHT AS THOUGH IT WERE A POINT SOURCE.

IMAGE ON SCREEN:



Q3

a)



- By GEOMETRY [SLAB IS RECTANGULAR]:

$$\theta_A = \theta_B \quad (A)$$

- SNELL'S LAW:

$$n_1 \sin\theta_t = n_2 \sin\theta_B$$

- SNELL'S LAW: (A)

$$n_1 \sin\theta_i = n_2 \sin\theta_A = n_2 \sin\theta_B = n_1 \sin\theta_t$$

$$\longrightarrow \quad \theta_i = \theta_t$$

BEAM is SHIFTED, BUT NOT DEFLECTED!

(Q3 (a) CONT.)

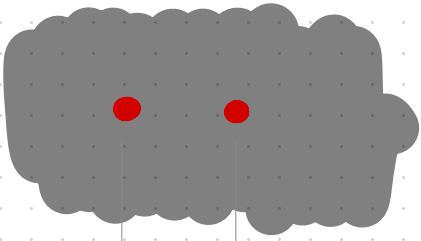
- AS n_2 INCREASES, RAY DEFLECTION INCREASES & SO SHIFT INCREASES.
  - IF $n_2 < n_1$, RAY SHIFTS IN OPPOSITE DIRECTION [TO THE RIGHT, IN OUR EXAMPLE]
- IF $\theta_i = 0$, DEFLECTION GOES TO ZERO ($\theta_A = \theta_i = 0$) SO SHIFT IS ZERO. IN GENERAL, SHIFT INCREASES W/ INCREASING θ_i.

b)

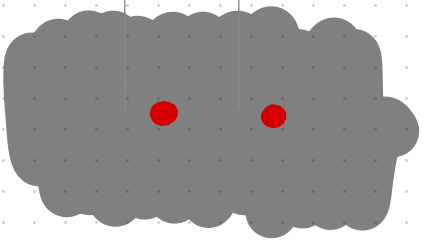
* ALL RAYS IN THIS PROBLEM ARE SAME COLOR [I.E. WAVELENGTH]. DIAGRAM COLORS ARE JUST FOR CLARITY.

IMAGE ON SCREEN

BEFORE SLAB:



AFTER SLAB INSERTED:



SPOTS SHIFTED RIGHT →

C) RAYS OF ALL COLORS EMITTED IN ALL DIRECTIONS. ONLY SOME RAYS HIT SCREEN

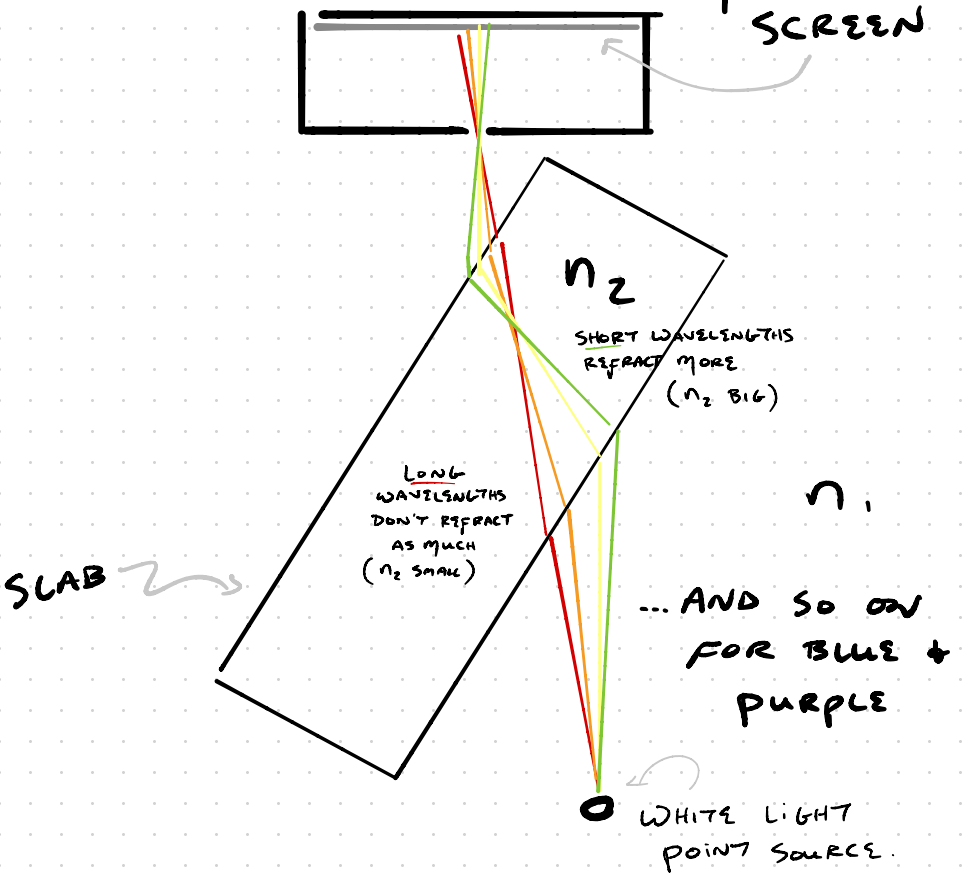


IMAGE ON SCREEN