AP Review # 17

Air 1.00

Liquid 1.33

Glass 1.52
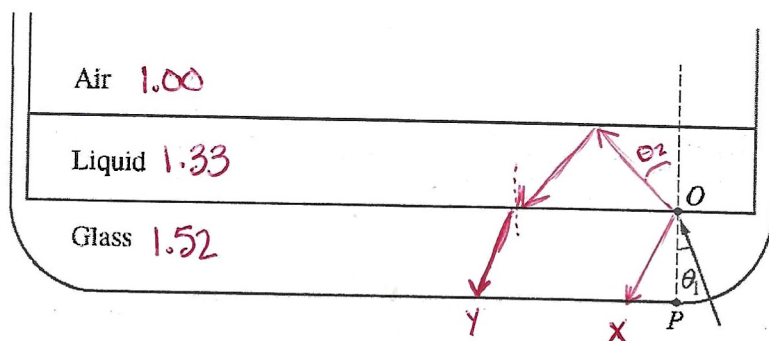
1. (10 points - suggested time 20 minutes)

The figure above shows a cross section of a drinking glass (index of refraction 1.52) filled with a thin layer of liquid (index of refraction 1.33). The bottom corners of the glass are circular arcs, with the bottom right arc centered at point O. A monochromatic light source placed to the right of point P shines a beam aimed at point O at an angle of incidence θ. The flat bottom surface of the glass containing point P is frosted so that bright spots appear where light from the beam strikes the bottom surface and does not reflect. When $\theta = \theta_1$, two bright spots appear on the bottom surface of the glass. The spot closer to point P will be referred to as X; the spot farther from P will be referred to as Y. The location of spot X and that of spot Y both change as θ is increased.

I missed this + "lost" this point

(a) In a coherent paragraph-length answer, describe the processes involved in the formation of spots X and Y when $\theta = \theta_1$ (Include an explanation of why spot Y is located farther from point P than spot X is and what factors affect the brightness of the spots.

When the beam of light strikes the glass-liquid boundary, some of it is reflected and some is refracted. The part that reflects creates spot X. The part that refracts then strikes the liquid-air boundary where it again partially reflects and partially refracts. The part ~~does~~ of that beam that reflects from the air-liquid boundary travels back through the liquid + glass to create spot Y.

The brightness of the spots depends on how much of the light is reflected instead of refracted. As more light reflects, the brightness increases.

(i) X is reflect glass-liquid
(i) Y is refract as enter + leave
(ii) Y is reflect at air liquid

(i) Y is farther, geometry of path
(i) brightness

Continued on back →

(b) When θ is increased to θ_2, one of the spots becomes brighter than it was before, due to total internal reflection.

   i. On the figure below, draw a ray diagram that clearly and accurately shows the formation of spots X and Y when $\theta = \theta_2$.
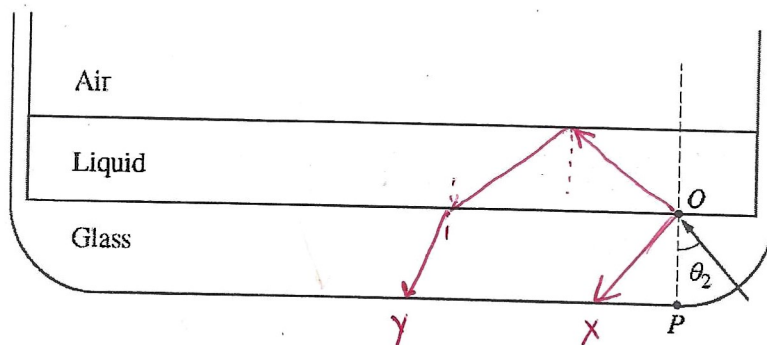
(1) X
(1) Y, correct bend
none in air

   ii. Which spot, X or Y, becomes brighter than it was before due to total internal reflection? Explain your reasoning.

(1)

Y would become brighter because all of the light would be reflected at the air-liquid interface instead of being split.

(c) When θ is further increased to θ_3, one of the spots disappears entirely.

   i. On the figure below, draw a ray diagram that clearly and accurately shows the formation of the remaining spot, X or Y, when $\theta = \theta_3$.

(1) • none in liquid

   ii. Indicate which spot, X or Y, disappears. Explain your reasoning in terms of total internal reflection.

(1) TIR at glass

Spot Y would disappear. As θ increases to θ_3 it exceeds the critical angle of the glass. All of the light is reflected at the liquid-glass interface instead of some continuing into the liquid to be reflected back to spot Y.