PHYS 408 March 24 2011

1)-In your own words, describe what makes a particular device a resonator. In your explanation use BOTH optical and non-optical examples of resonators.

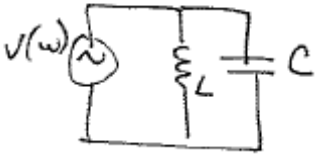
2) List some key features of resonators and explain why we as physicists and engineers are interested in such devices and behaviour

PHYS 408 March 24 2011

1)-In your own words, describe what makes a particular device a resonator. In your explanation use BOTH optical and non-optical examples of resonators.

2) List some key features of resonators and explain why we as physicists and engineers are interested in such devices and behaviour

A resonator stores or "traps" energy via constructive interference @ certain frequencies (termed natural frequencies)

Examples: 

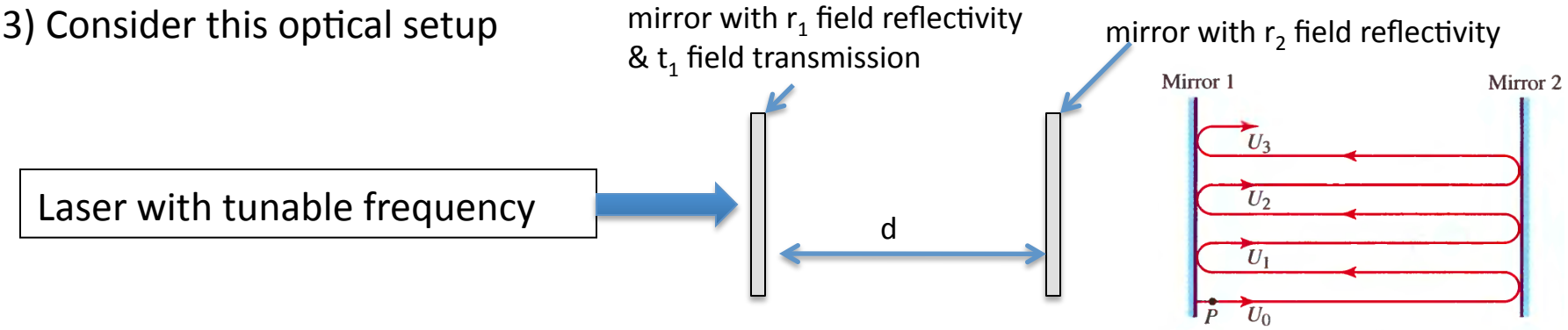
(electrical) quartz oscillator, bridges (~~mechanical~~ mechanical)

flutes (acoustical), 

(optical, called Fabry-Perot cavity)

1) can "amplify" signals
2) can be used as filters (in FM radio for example)
3) ~~bridges~~ w/o correct design ~~choice~~ choices bridges, buildings, etc can have natural frequencies which can lead to damage
4) Necessary for laser cavities

3) Consider this optical setup



a) Describe qualitatively what occurs to the intensity inside the two mirrors as the laser wavelength is changed

b) The expression for the intensity is shown to the right. Give the steps for how this expression was obtained and define r, ϕ in terms of the parameters above. Sketch and label a plot of I as the laser frequency is scanned.

$$I = |U|^2 = \frac{|U_0|^2}{|1 - |\mathrm{r}|e^{-j\varphi}|^2} = \frac{I_0}{1 + |\mathrm{r}|^2 - 2|\mathrm{r}|\cos\varphi},$$

be written as

$$I = \frac{I_{\max}}{1 + (2\mathcal{F}/\pi)^2 \sin^2(\varphi/2)}, \qquad I_{\max} = \frac{I_0}{(1 - |\mathrm{r}|)^2}.$$

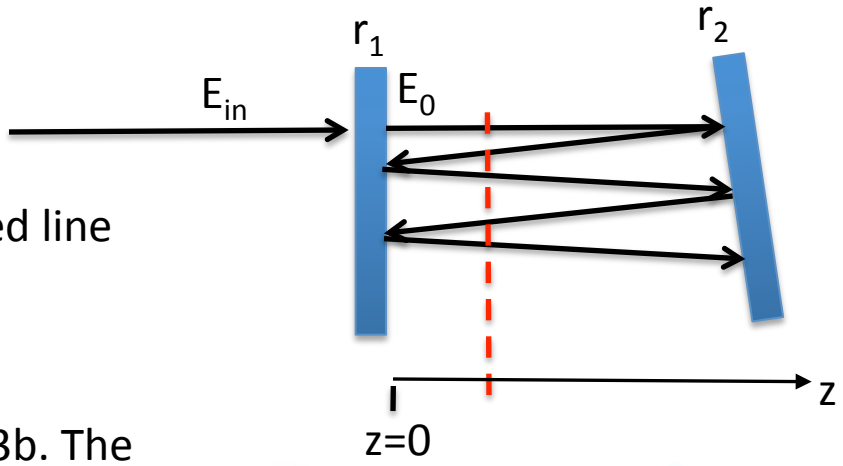
$|U_0|^2$ is the intensity of the initial wave and

4) Consider extremes of your expression (r_1 and $r_2 \longrightarrow 1$, etc) in 3b to check and make sure your expression and plot make sense physically. Argue they do with your own words.

$$\mathcal{F} = \frac{\pi\sqrt{|\mathrm{r}|}}{1 - |\mathrm{r}|}$$

5) Now Consider the following Fabry-Perot Cavity with a slightly unparallel mirror pair separated by a distance d

a) Now rotate the mirror 2 to be parallel and write down the first 5 terms of the electric field at the plane shown by the dotted line

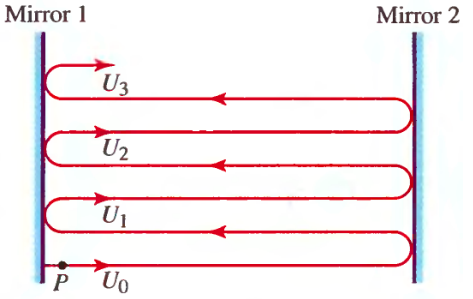


6a) Compare your result of 5a with exercise 3b. The two total electric fields are different in nature. What are the differences?

6b) So what exactly did we calculate in 3b?

7a) Sketch the field E(z) and intensity I(z) of a representative resonance inside the cavity

b) How does this relate to I shown on the right and what we calculated in 3b?



$$I = |U|^2 = \frac{|U_0|^2}{|1 - |\mathrm{r}|e^{-j\varphi}|^2} = \frac{I_0}{1 + |\mathrm{r}|^2 - 2|\mathrm{r}|\cos\varphi},$$

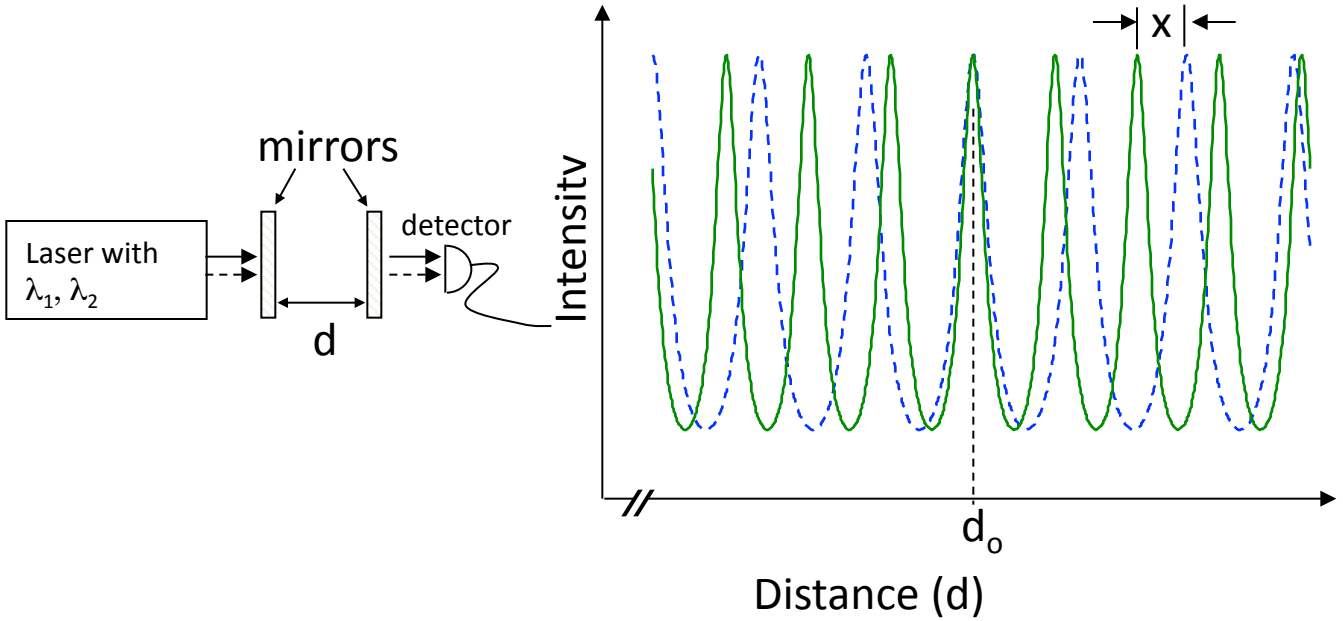
be written as

$$I = \frac{I_{\max}}{1 + (2\mathcal{F}/\pi)^2 \sin^2(\varphi/2)}, \qquad I_{\max} = \frac{I_0}{(1 - |\mathrm{r}|)^2}.$$

$|U_0|^2$ is the intensity of the initial wave and

$$\mathcal{F} = \frac{\pi\sqrt{|\mathrm{r}|}}{1 - |\mathrm{r}|}$$

A laser that produces two wave lengths (λ_1=500 nm λ_2=600 nm) is directed toward a Fabry-Perot resonator as shown. A detector on the other side measures two signals as the mirror separation (d) is scanned.



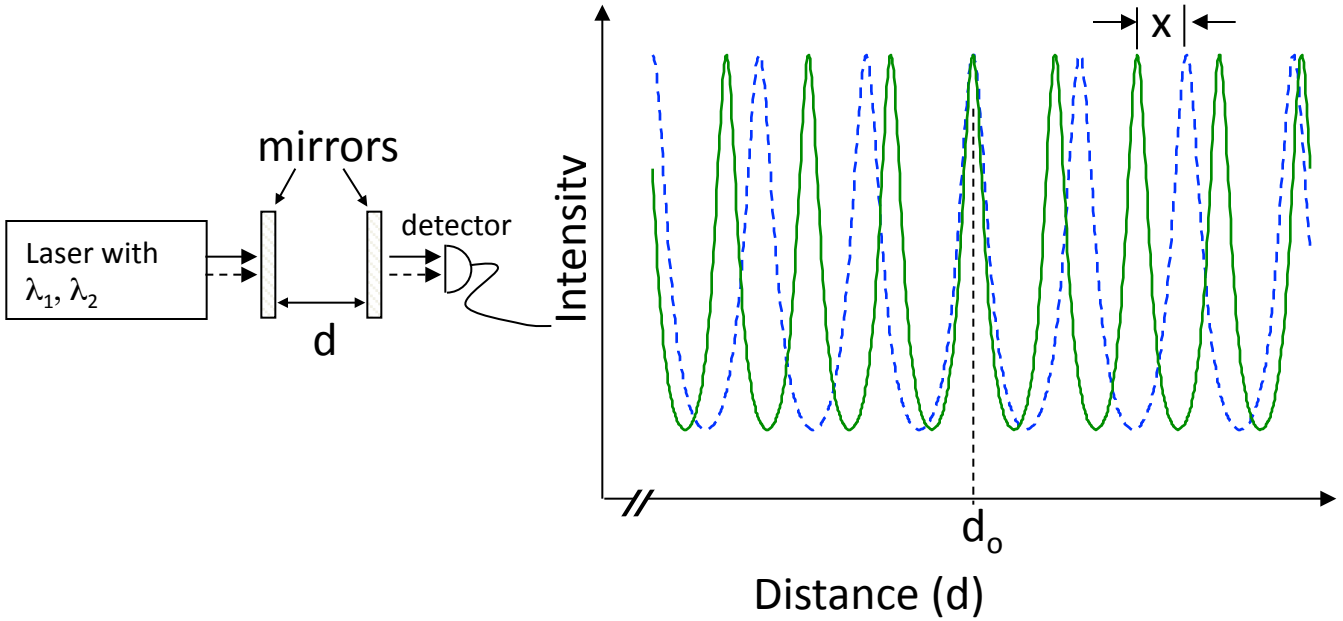
Which wavelength corresponds to the solid curve in the detector measurement?

(A) λ_1 is the solid curve

(B) Nether wavelength is the solid curve

(C) λ_2 is the solid curve

A laser that produces two wave lengths (λ_1=500 nm λ_2=600 nm) is directed toward a Fabry-Perot resonator as shown. A detector on the other side measures two signals as the mirror separation (d) is scanned.



Which value below is a possible value for d_o?

(A) d_o=1.4 mm

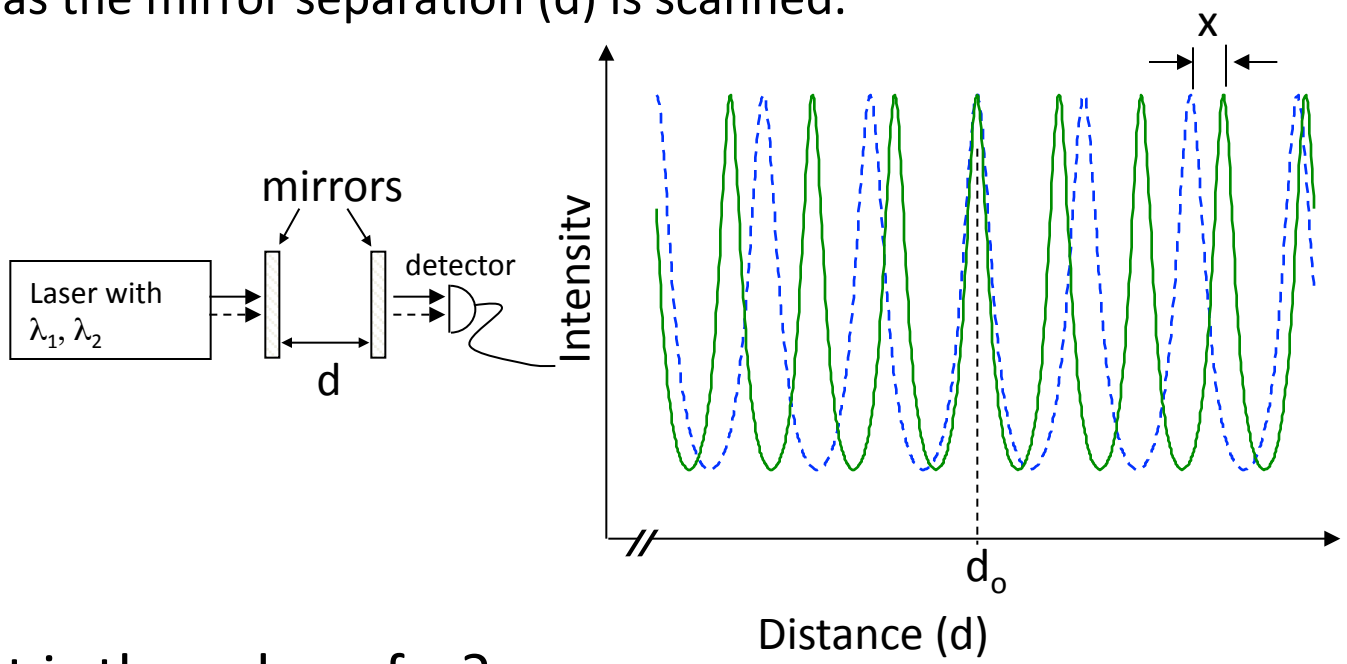
(B) d_o=800 nm

(C) d_o=3.0 m

(D) d_o=12 m

(E) Not enough info is given

A laser that produces two wave lengths (λ_1=500 nm λ_2=600 nm) is directed toward a Fabry-Perot resonator as shown. A detector on the other side measures two signals as the mirror separation (d) is scanned.



What is the value of x ?

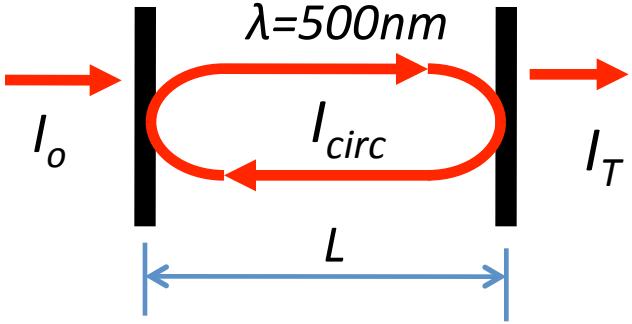
(A) Not enough info is given

(B) x= 150 nm

(C) x= 100 nm

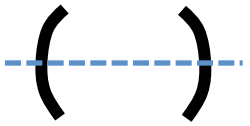
(D) x= 300 nm

Below are various statements regarding two-mirror cavities. Which of these is incorrect?



(A) After each round trip in the cavity, the beam returns to its original shape (i.e. wavefront curvature.

(B) Only concave mirrors can lead to a stable 2 mirror optical cavity:



(C) At t=0, immediately after the incoming laser is aimed at a high Finesse cavity, most of the light does not go into the cavity, most of it is reflected.

(D) When on resonance and in steady state, the circulating optical power inside a cavity is always larger than the incoming optical power

(E) More than one statement is not true