NBE-E4310 - Biomedical Ultrasonics

EXERCISE 2 (30p)

Independent/group work 31.1.2019 at 12-14; correct solutions 7.2.2019 at 12-14

Submission: Please submit your responses via MyCourses as one zip file containing your responses in pdf and Matlab format.

The deadline for submitting your Exercise 2 responses is at 11:00 AM on Feb 7, 2019.

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1. Common measures of intensity (5 p)

A focused continuous wave is traveling along the *z-axis*. The file (I_ta.txt) contains a *z-slice* of intensity data in the *x-y* plane near the focus of the beam. Each element corresponds to the time average intensity (in W/cm^2) in a 100 μm by 100 μm area.

a) Plot the time average intensity in the x-y plane near the focus ands calculate the total power of the beam within a 2 mm distance from the center of the beam in the *x-y* plane. (3p)

b) Calculate the I_{sata} in the region defined in a). (2p)

2. Radiation Force (5p)

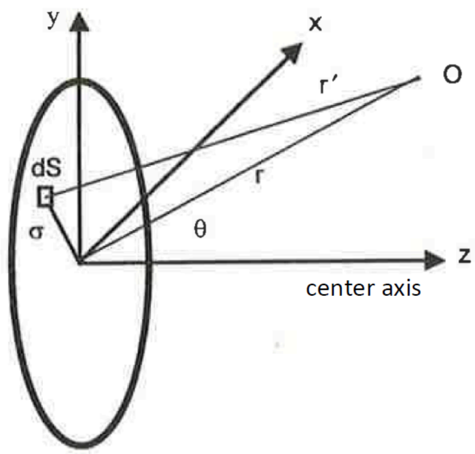
You apply the field presented in Problem 1 to a perfect absorber. The entire power defined by I_ta.txt is absorbed.

a) What is the radiation force exerted on the absorber? (3p)

b) What is the maximum Langevin pressure applied to the interface, given that the interface is at the focus of the beam? (2p)

3. Transducers (20p)

Consider a circular ultrasound transducer of a radius $a = 6\ \mathrm{mm}$ and operating frequency of $f_0 = 1\ \mathrm{MHz}$ in water.



a) Calculate numerically the pressure field at the center axis z as a complex presentation. Plot the envelope of the pressure at the center axis in the near field. (5p)

Use the following expression:

$$p_z(r) = i\frac{p_0 k}{2\pi}\int\int\frac{e^{-\mathrm{ikr}}}{r}\mathrm{dS}$$

Consider the parameters given below:

$$p_0 = 1\ \mathrm{MPa}$$
$$\text{transducer element size} = 50\ \mu m$$

b) Plot the numerical expression and analytical expression of the pressure at the centre axis. (5p)

Use the following analytical expression:

$$p_z(z) = 2p_0\left|\sin\left\{\frac{\mathrm{kz}}{2}\left[\sqrt{1+\left(\frac{a}{z}\right)^2} - 1\right]\right\}\right|$$

c) Consider the complex vector $p_z(z)$ representig the pressure at center axis. Plot an animation of 8 cycles of the pressure signal over the time $p_z(z)\,e^{i\omega t}$. (5p)

d) Calculate numerically the pressure field at the center plane xy as a complex presentation. Plot the envelope of the pressure at the center plane xy in the near field. Then plot an animation of 8 cycles of the pressure field over the time $p_{\mathrm{xz}}(x,z)\,e^{i\omega t}$ (5p)