NBE-E4310 - Biomedical Ultrasonics

EXERCISE 4 (30p)

Independent/group work 7.3.2019 at 12-14; correct solutions 14.3.2019 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 4 responses is at 11:00 AM on Mar 14, 2019.

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1. Cavitation (20p)

Based on the article https://doi.org/10.1121/1.402855:

a) implement in matlab (you can find a template script on the course page) the following equation describing the motion of a single bubble in a spatially uniform acoustic field.

$$\left(1-\frac{\mathrm{dR}}{\mathrm{dt}}\frac{1}{c}\right)R\frac{\mathrm{d}^2}{\mathrm{d}t^2}R+\frac{3}{2}\frac{\mathrm{dR}^2}{\mathrm{dt}}\left(1-\frac{\mathrm{dR}}{\mathrm{dt}}\frac{1}{3c}\right)=\left(1+\frac{\mathrm{dR}}{\mathrm{dt}}\frac{1}{c}\right)\frac{1}{\rho_l}\left[p_B(R,t)-p_A\left(t+\frac{R}{c}\right)-p_\infty\right]+\frac{R}{\rho_l c}\frac{\mathrm{dp}_B(R,t)}{\mathrm{dt}}$$

Then plot the relative bubble boundary displacement $R(t)/R_0$. (5p)

b) Determine the pressure threshold that enables inertial cavitation, that can be considered as when the $R(t) > R_0$ where $2R_0$ is the initial bubble radius. (5p)

c) Plot the bubble boundary velocity for the following cases: (5p)

1) $R_{0,1} = 1\mu m$
2) $R_{0,2} = 5\mu m$
3) $R_{0,3} = 10\mu m$

d) Plot the bubble boundary acceleration for the same cases as in the previous point. What differences do you observe? Why? (5p)

2. Radiation force in absorbing medium (2p)

What is the radiation pressure gradient in muscle tissue at $1\ \mathrm{MHz}$, when $I_{\mathrm{spta}} = 5\ \frac{W}{\mathrm{cm}^2}$?

3. Acoustic levitation (5p)

You have a polystyrene ball with a radius of 1 mm, and a λ / 2 levitator operating at 20 kHz. What is the minimum PPP in the standing wave that can levitate the sphere in air? Convert this peak pressure to SPL.

4. Acoustic streaming (3p)

You are using a HIFU setup at $1\ \mathrm{MHz}$, where the $I_{\mathrm{spta}} = 1\ \frac{W}{\mathrm{cm}^2}$. The geometric factor G is 2.

a) What is the streaming velocity in water at the focus?

b) What is the streaming velocity in blood at the focus?