2 Assignment 2

Question No.	1	2	3	4	5	6	Total
Score	12%	16%	17%	16%	18%	21%	100%

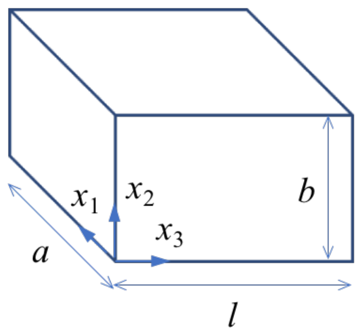
good example to review the waves in retangular tube

Q 2.1. Show that a closed box with sides of length a, b and l resonates at frequencies

$$\omega = c\pi\left[\left(\frac{m}{a}\right)^2+\left(\frac{n}{b}\right)^2+\left(\frac{p}{l}\right)^2\right]^{1/2}$$

where m, n and p are integers. Hence determine the three lowest resonant frequencies of a rigid walled box with sides of length 1 m by 0.2 m by 0.3 m.

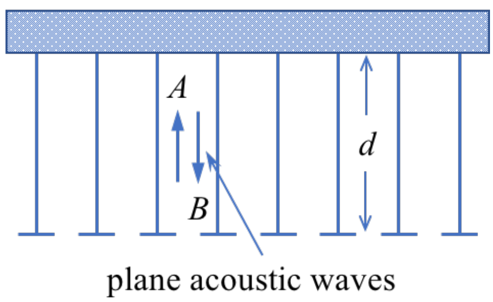
Total: [12%]



Q 2.2. For an acoustic liner of the form shown in the figure, the porosity (i.e. open area ratio) of the perforated sheet is α, the pressure loss across a hole is $0.1\rho_0 c u_h$, where u_h is the acoustic velocity in the hole (i.e. $u_h = u_n/\alpha$), and the honeycomb depth is d. Consider plane acoustic waves propagating in the honeycomb.

(i) Determine the surface impedance p'_s/u_n. [9%]

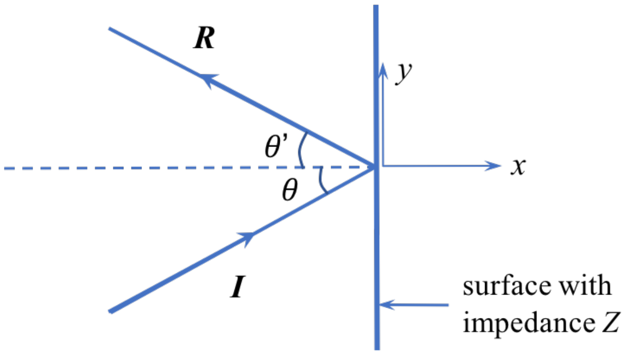
(ii) For this liner geometry, what honeycomb depth would you choose to optimally absorb sound of 1.45 kHz at an ambient temperature of 600 K? [7%]



结构？ holes+honeycomb?
p_s？

Total: [16%]

Q 2.3. A plane wave of amplitude I travelling at an angle θ to the positive x axis, where $0 \leqslant \theta \leqslant \pi/2$, is incident on an infinite plane wall at $x = 0$. The complex impedance of the wall is Z.



(i) Show that the complex amplitude of the reflected wave, R, is given by

$$\frac{R}{I} = \frac{Z\cos\theta - \rho_0 c}{Z\cos\theta + \rho_0 c}$$

where ρ_0 and c are the density and sound speed of the air for $x < 0$. [7%]

(ii) In the case when Z is a purely real and positive constant, determine the minimum and maximum possible values of $|R/I|$, being careful to distinguish between the cases $Z > \rho_0 c$ and $Z < \rho_0 c$. [8%]

(iii) What happens to $|R/I|$ when Z is purely imaginary? [2%]

Total: [17%]

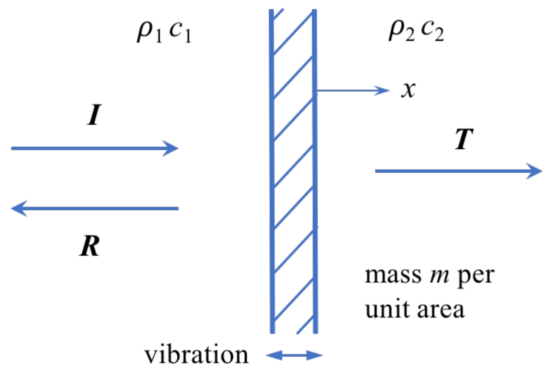
Q 2.4. A thin wall of mass per unit area m is located in the plane $x = 0$ and is free to make small oscillations in the x-direction. The wall separates two acoustic media, of sound speed and density c_1 and ρ_1 in $x < 0$ and c_2 and ρ_2 in $x > 0$. A plane sound wave is normally incident on the wall from $x < 0$.

motion eq and velocity continuity*

(i) Determine an expression for the ratio of the magnitudes of the reflected and incident pressures, $|R/I|$, where R and I are the complex amplitudes of the reflected and incident waves, respectively. [12%]

(ii) Identify two dimensionless numbers which determine the size of this quantity, and explain their physical significance. [4%]

Total: [16%]



Q 2.5. A ray travels through $x \geqslant 0$ in a medium with spatially-varying sound speed

$$c(x) = c_0 e^{\alpha x}$$

where c_0 and α are constants. The ray passes through the origin, where it makes an angle $\beta > 0$ to the positive x axis.

(i) Determine the equation of the ray path. constant [8%]

(ii) Sketch the shape of the ray path in the cases $\alpha > 0$ and $\alpha < 0$, indicating the important values on the axes. x-∞, sin^-1(x)-pi [10%]

You may assume without proof that

$$\int \frac{e^{\alpha x}}{\sqrt{1 - \sin^2 \beta \, e^{2\alpha x}}} \, \mathrm{d}x = \frac{\sin^{-1}(\sin \beta \, e^{\alpha x})}{\alpha \sin \beta} + C$$

where C is a constant to be determined.

Total: [18%]

Q 2.6. Near a fjord where cold water enters the sea, the speed of sound c has a maximum at a depth of $x = 100$ m. The speed of sound increases linearly with depth from 1450 m s^{-1} at the sea surface to 1500 m s^{-1} at the depth of $x = 100$ m. At depths greater than 100 m, c decreases with increasing depth.

(i) Explain how the angle θ between a ray and the x-axis varies with depth. Sketch the ray pattern produced by a source on the surface. [8%]

Consider the ray that forms the upper boundary of the shadow zone produced by a source on the sea surface.

$\boxed{\text{(ii)}}$ At what angle θ_0 does this ray leave the source? [3%]

$\boxed{\text{(iii)}}$ At what horizontal distance from the source does this ray again meet the surface?
圆方程中的符号可变 [10%]

Total: [21%]