

RESERVE DESK

M.E. Ph.D. Qualifier Exam
Fall Semester 2003

DEC 11 2003

GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

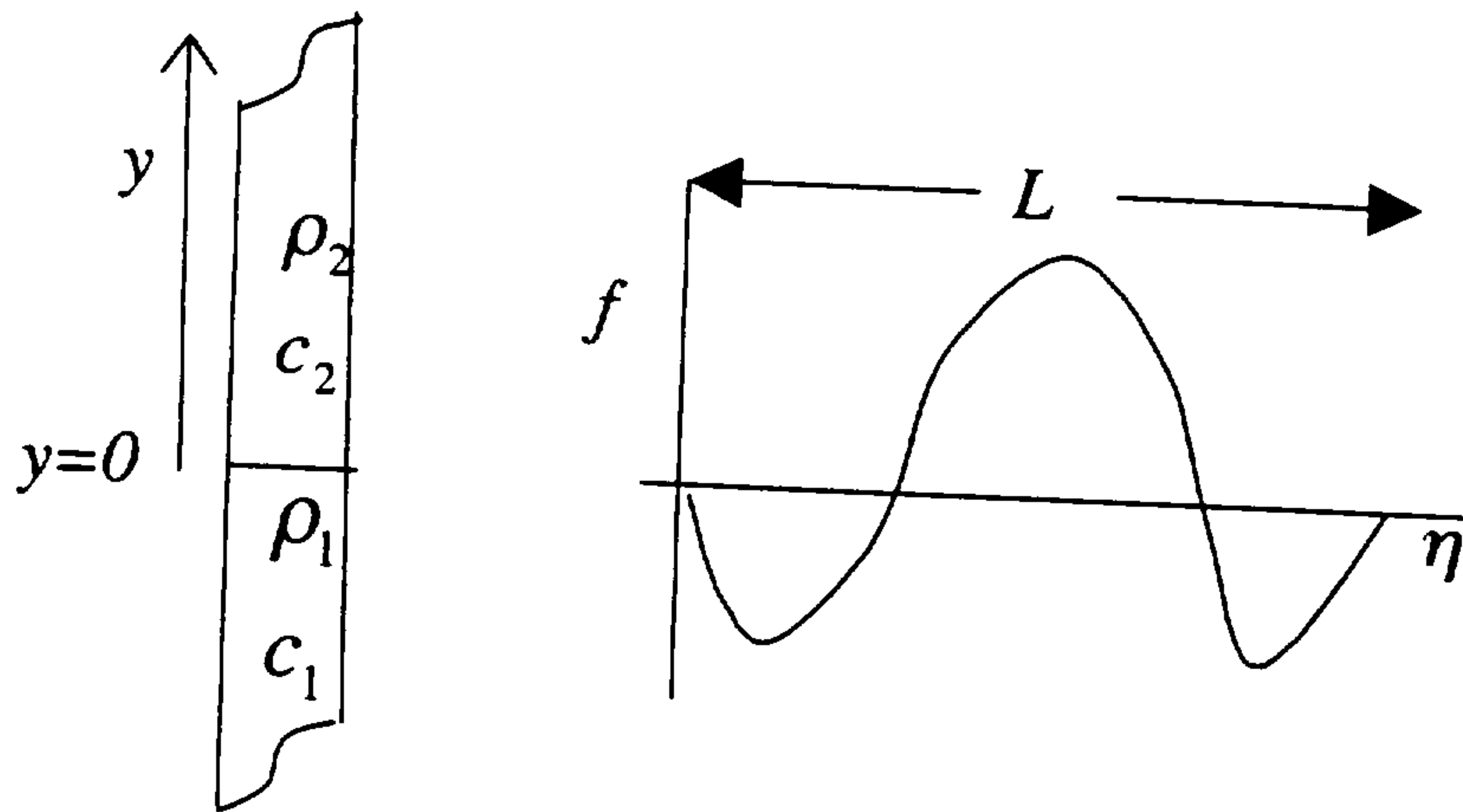
Ph.D. Qualifiers Exam - Fall Semester 2003

Acoustics
EXAM AREA

Assigned Number (DO NOT SIGN YOUR NAME)

* Please sign your name on the back of this page —

ANSWER ALL THREE QUESTIONS



1. A rigid walled infinitely long pipe is filled with two immiscible fluids. The first has sound speed c_1 and density ρ_1 and the second sound speed c_2 and density ρ_2 with $\rho_2 < \rho_1$. The interface between the two fluids is at $y = 0$ as shown in the figure above. A one dimensional sound wave propagating in fluid 1 the positive y direction is given by

$$p(y, t) = p_0 f(y - c_1 t)$$

where f is the function shown above which has the following properties:

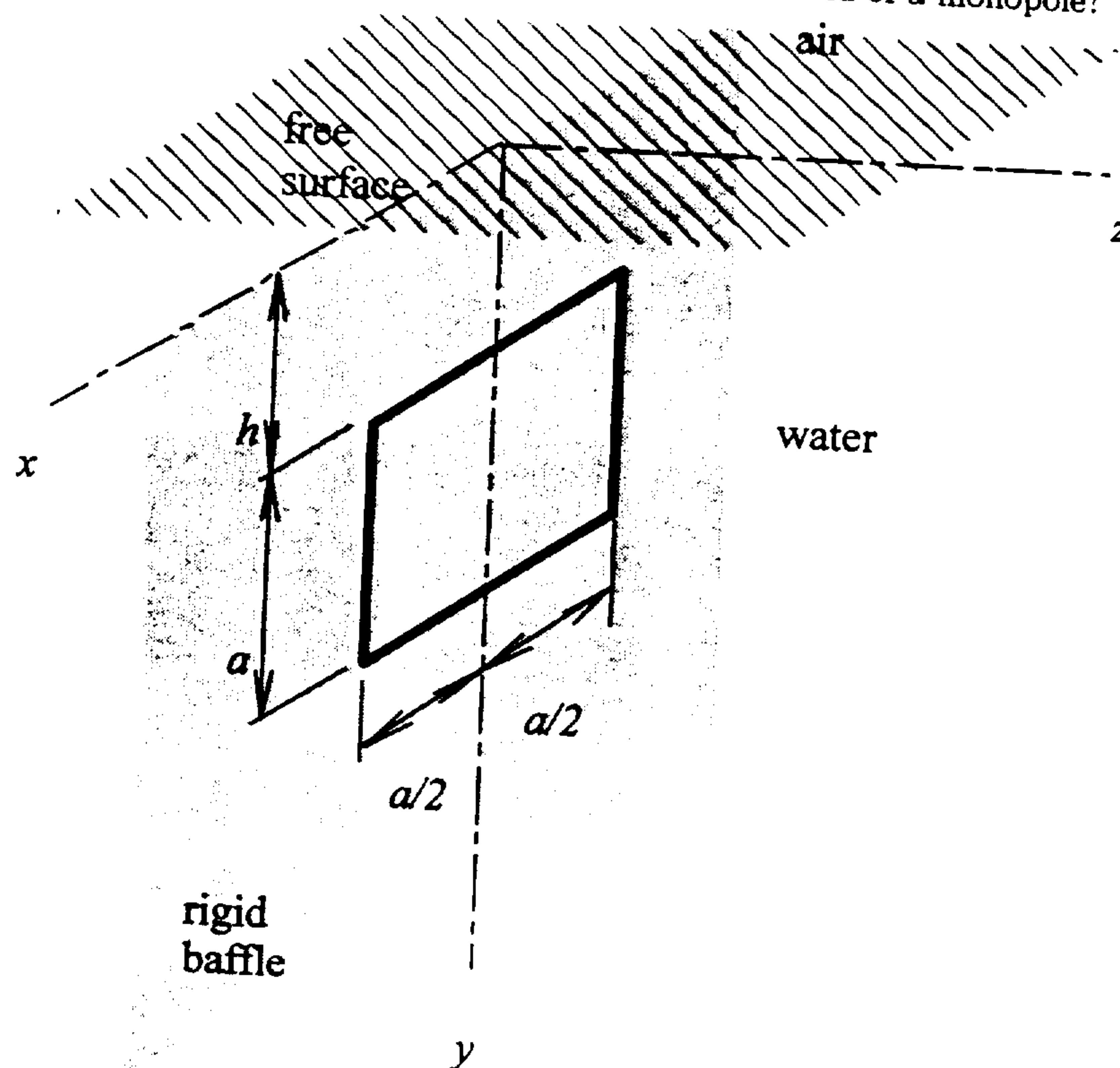
$$f(\eta) = 0 \quad \eta < 0 \text{ or } \eta > L$$

$$\int_0^L [f(\eta)]^2 d\eta = L$$

- What is the energy of the initial pulse?
- Derive expressions for the reflected and transmitted pulses.
- Show explicitly that the energy is conserved. That is, show that the energy of the reflected and transmitted pulse equals the energy of the incident pulse.

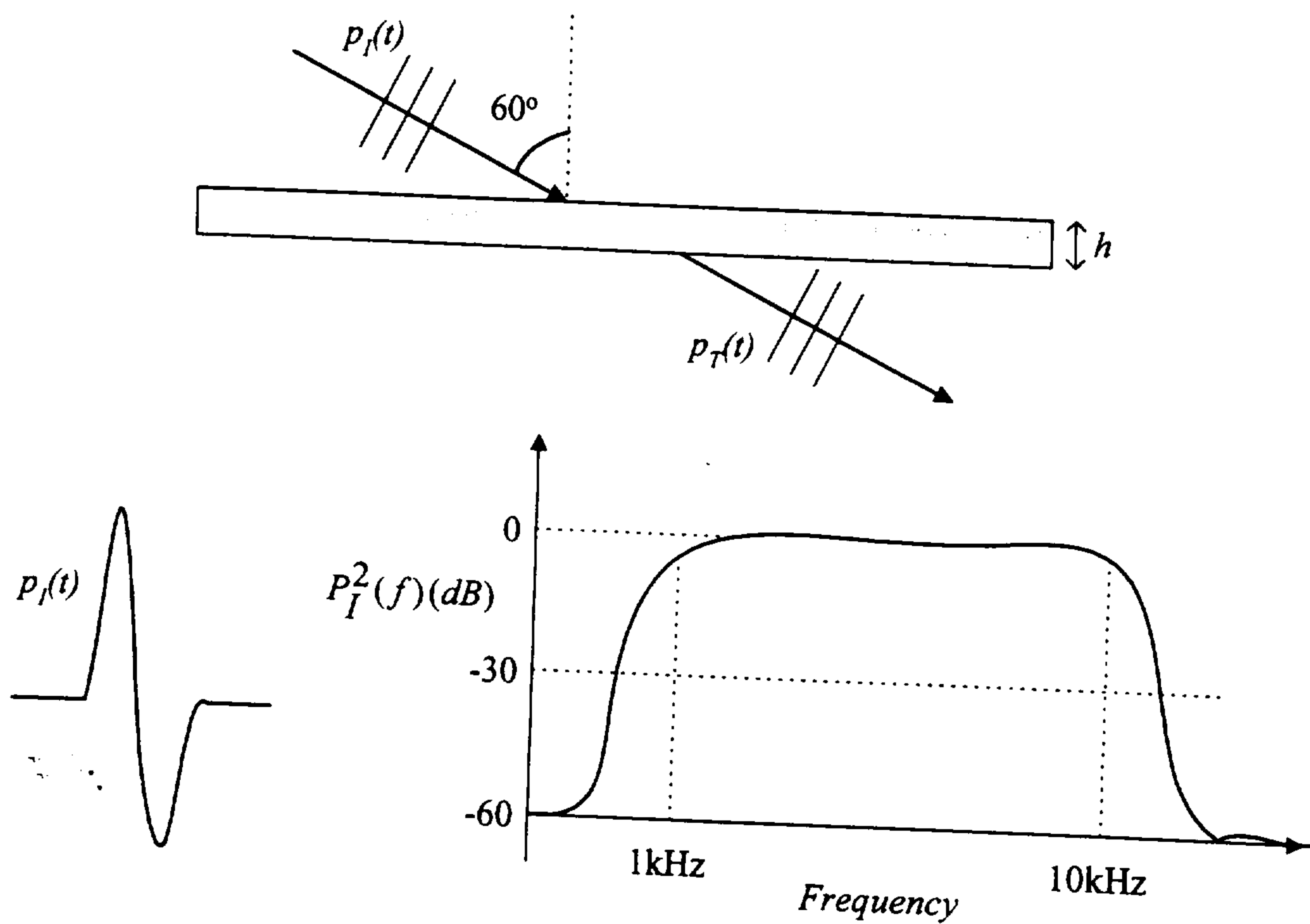
2. The sketch depicts an underwater square transducer contained within a large rigid baffle. The baffle is oriented in the vertical plane and extends to the free surface. The edge dimension of the transducer is a , and the upper edge is at depth h below the free surface. The transducer oscillates at frequency ω with velocity amplitude v_0 that is uniform across the transducer's face.

- Derive an expression for the complex amplitude of the pressure P in the farfield as a function of spherical coordinates for which z is the polar axis and r measures the distance from the xyz origin.
- Derive an expression for the radiated power. The result may be left in integral form.
- Qualitatively, for what combination of parameters a , h , $k = \omega/c$, and r would it be reasonable to anticipate that the spatial dependence of P would resemble the field of a vertical dipole?
- Qualitatively, for what combination of parameters a , h , $k = \omega/c$, and r would it be reasonable to anticipate that the spatial dependence of P would resemble the field of a monopole?



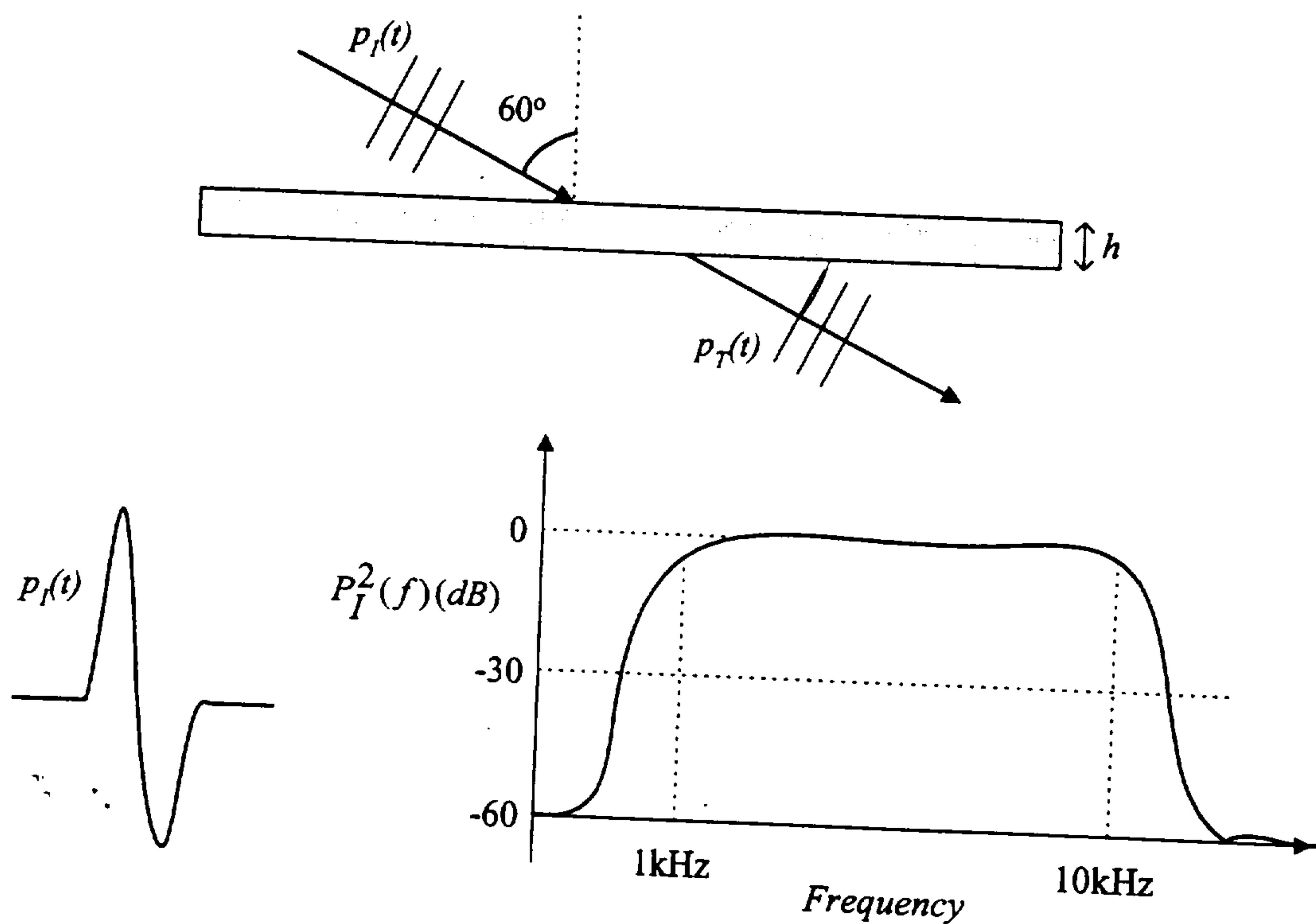
3. Consider a transient plane pressure wave incident on a 3mm thick aluminum plate in air at an angle of 60° as shown in the figure. The incident pressure signal $p_I(t)$ has a broad frequency spectrum in the 1-10kHz range as seen from its spectral density given below.
- Determine and plot the spectral density of the transmitted pressure wave, $P_T^2(f)$. Clearly indicate any assumptions used in your calculations. You can assume that the plate is infinitely large in the lateral direction and ignore attenuation in the materials.
 - Qualitatively estimate and sketch the transmitted pressure signal $p_T(t)$ in time domain. Explain your reasoning.

The properties of air are $\rho_{air} = 1.3 \text{ kg/m}^3$, $c_{air} = 340 \text{ m/s}$. The material constants for aluminum are given as $\rho_{Al} = 2700 \text{ kg/m}^3$, Young's modulus, $E = 72 \times 10^9 \text{ Pa}$, and the Poisson's ratio, $\nu = 0.34$. Note that the flexural wave speed in a thin plate is given by the dispersion relation $c_{pl}(\omega) = \left(\frac{B}{h\rho_{Al}}\right)^{1/4} \sqrt{\omega}$, where h is the plate thickness and $B = \frac{Eh^3}{12(1-\nu^2)}$ is the flexural rigidity.



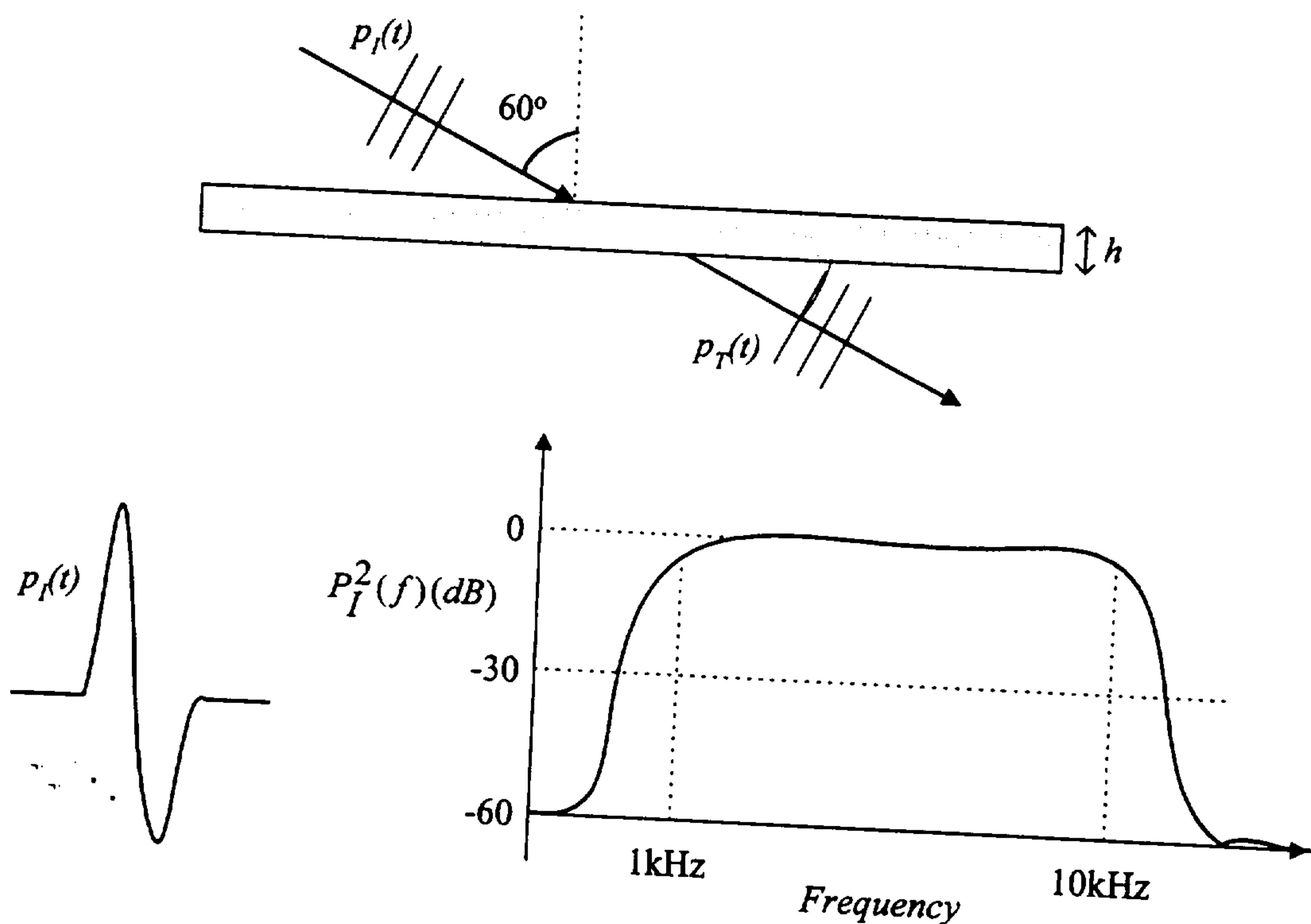
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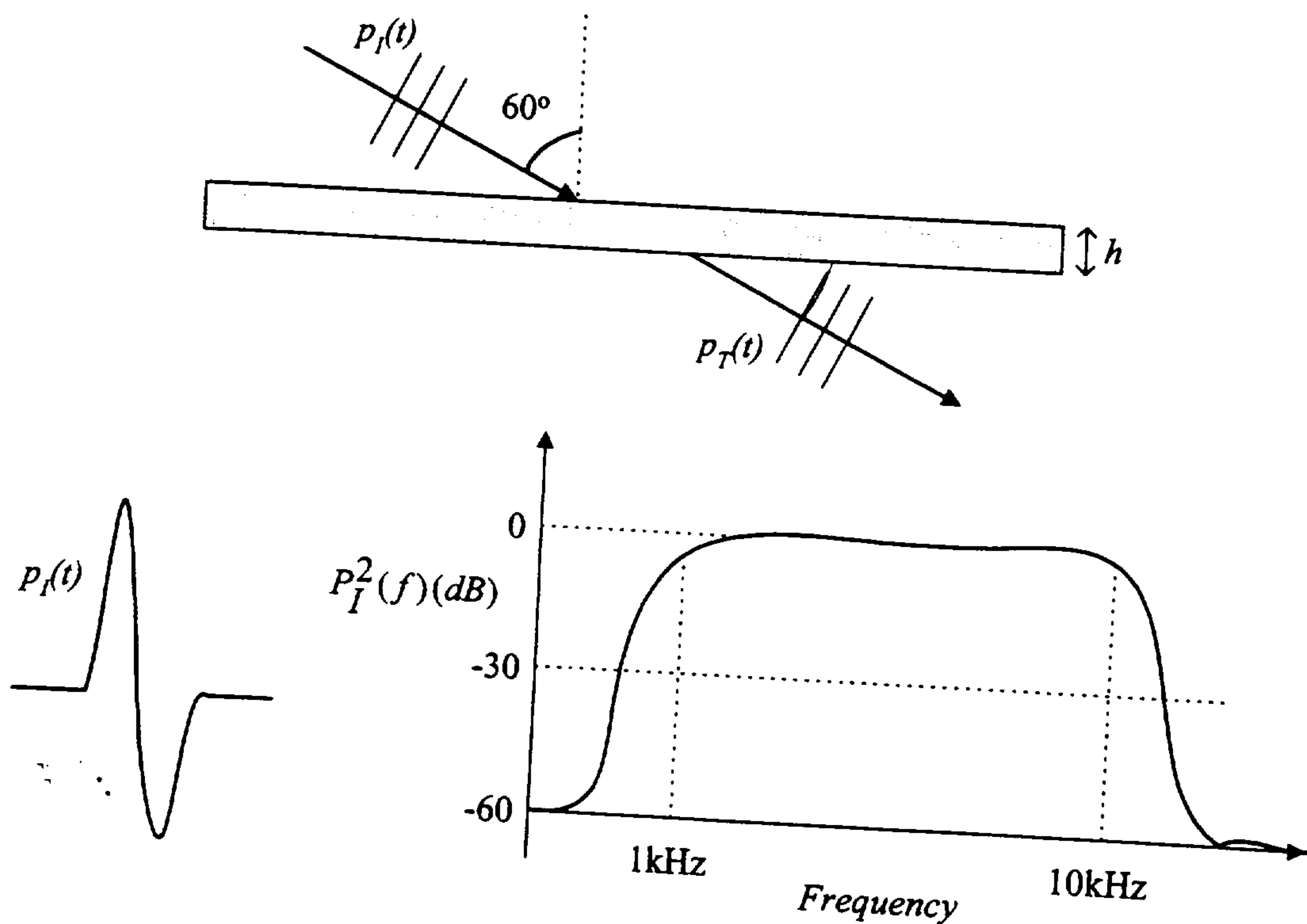
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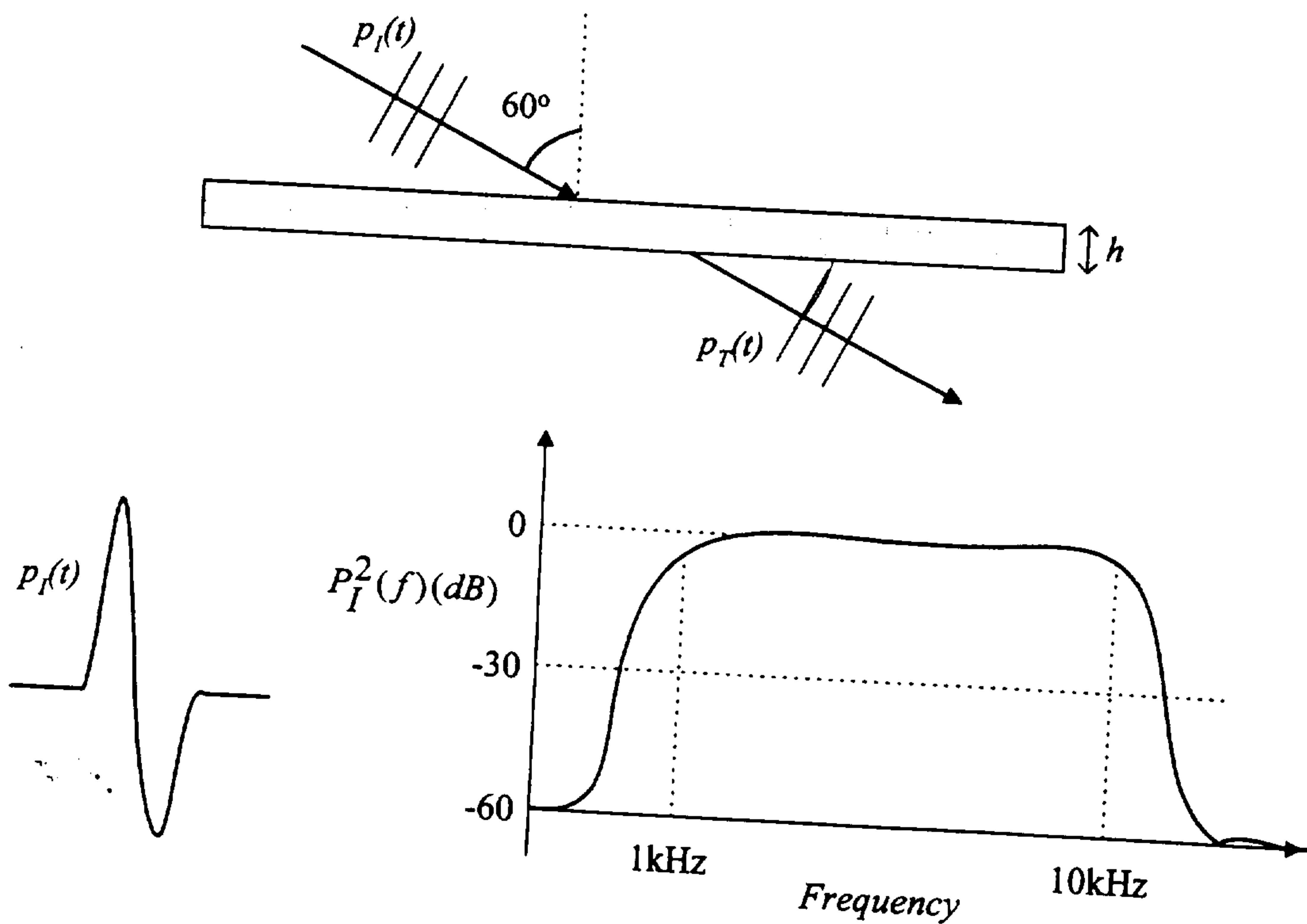
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