662.

Problem 46.25 (RHK)

A circular diaphragm 60 cm *in diameter oscillates at a frequency of* 25 kHz *in an underwater source of sound used for submarine detection. Far from the source the sound intensity is distributed as a diffraction pattern for a circular hole whose diameter equals that of the diaphragm. Assuming that the speed of sound in water to be* 1450 m s^{-1}, *we have to find the angle between the normal to the diaphragm and the direction of the first minimum.* (b) *We have to repeat the calculation for a source having an* (*audible*) *frequency of* 1.0 kHz.

Solution:

(a)

The speed of sound in water is $v = 1450 \text{ m s}^{-1}$.

The wavelength of sound waves of frequency 25 kHz will be

$$\lambda = \frac{1450}{25\times10^3} \text{ m} = 5.8\times10^{-2} \text{ m}.$$

In a diffraction from a circular hole of diameter *a* the position of first minima is determined by the relation

$$\theta = \frac{1.22 \times \lambda}{a}.$$

It is given that the diameter of the circular diaphragm is

$a = 60 \text{ cm} = 0.6 \text{ m}.$

Therefore, angle θ will be

$$\theta = \frac{1.22 \times 5.8 \times 10^{-2}}{0.6} \text{ rad} = 0.1179 \text{ rad} = 6.75^0.$$

(b)

Let us repeat the calculation for oscillation of diaphragm with 1.0 kHz frequency. The wavelength of the sound waves will be

$$\lambda = \frac{1450}{1.0 \times 10^3} \text{ m} = 1.45 \text{ m}.$$

As $\lambda > a$, we may not be able to see the first diffraction minimum. Note

$$\frac{1.22 \times \lambda}{a} = \frac{1.22 \times 1.45}{0.6} = 2.94,$$

and cannot be satisfied for any θ.