

## QUES 05:-

A SONAR system fixed in a submarine operates at a frequency 40.0 kHz. An enemy submarine moves towards the SONAR with a speed of 360 km h<sup>-1</sup>. What is the frequency of sound reflected by the submarine? Take the speed of sound in water to be 1450 ms<sup>-1</sup>.

**Sol.** Operating frequency of the SONAR system,  $\nu = 40$  kHz

Speed of the enemy submarine,  $\nu_e = 360 \text{ km/h} = 100 \text{ m/s}$

Speed of sound in water,  $\nu = 1450 \text{ m/s}$

The source is at rest and the observer (enemy submarine) is moving toward it. Hence, the apparent frequency ( $\nu'$ ) received and reflected by the submarine is given by the relation:

$$\begin{aligned}\Rightarrow \nu' &= \left( \frac{\nu + \nu_e}{\nu} \right) \nu \\ &= \left( \frac{1450 + 100}{1450} \right) \times 40 = 42.76 \text{ kHz}\end{aligned}$$

The frequency ( $\nu''$ ) received by the enemy submarine is given by the relation:

$$\Rightarrow \nu'' = \left( \frac{\nu}{\nu + \nu_s} \right) \nu'$$

Where,  $\nu_s = 100 \text{ m/s}$

So, frequency of sound received is:

$$\Rightarrow \nu'' = \left( \frac{1450}{1450 - 100} \right) \times 42.76 = 45.93 \text{ kHz}$$