11.15

EE23BTECH11029 - Kanishk

Question:

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/hr. What is the frequency of sound reflected by the submarine? Take the speed of sound in water to be 1450 m/s.

Solution:

Parameter	Description	Value
V	Speed of sound in water	1450m/s
V_e	Speed of enemy submarine	100m/s
$Vrel$	Relative velocity between both submarine	1550m/s
f	Frequency of SONAR wave	40kHz
$y\left(x,t\right)$	Equation of SONAR wave	$A\sin\left(2\pi ft-\frac{2\pi}{\lambda}x+\phi\right)$
λ	Wavelength of SONAR wave	3.625cm
f'	Frequency observed by enemy submarine	42.76kHz
λ_2	Wavelength of reflected wave	3.157cm
$T=\frac{1}{f'}$	Time period of reflected wave	23.38s
$y_2\left(x,t\right)$	Equation of reflected wave as observed from submarine	$A\sin\left(2\pi f''t-\frac{2\pi}{\lambda_2}x+\phi\right)$

TABLE 0
INPUT PARAMETERS

Let us assume that the wave is reflected completely from enemy submarine.

From Table 0 :

$$Vrel = V + V_e \tag{1}$$
$$f' = Vrel/\lambda \tag{2}$$
$$= \left(\frac{V+Ve}{V}\right)f \tag{3}$$
$$= \left(\frac{1450+100}{1450}\right)40 \tag{4}$$
$$\implies f' = 42.76kHz \tag{5}$$

$$\lambda_2 = T\left(V - V_e\right) \tag{6}$$
$$= \left(\frac{V-V_e}{f'}\right) \tag{7}$$
$$f'' = V/\lambda_2 \tag{8}$$
$$\implies f'' = \left(\frac{V}{V-V_e}\right)f' \tag{9}$$
$$\therefore f'' = 45.92kHz \tag{10}$$

Let us assume that amplitude of both waves is $1cm$.

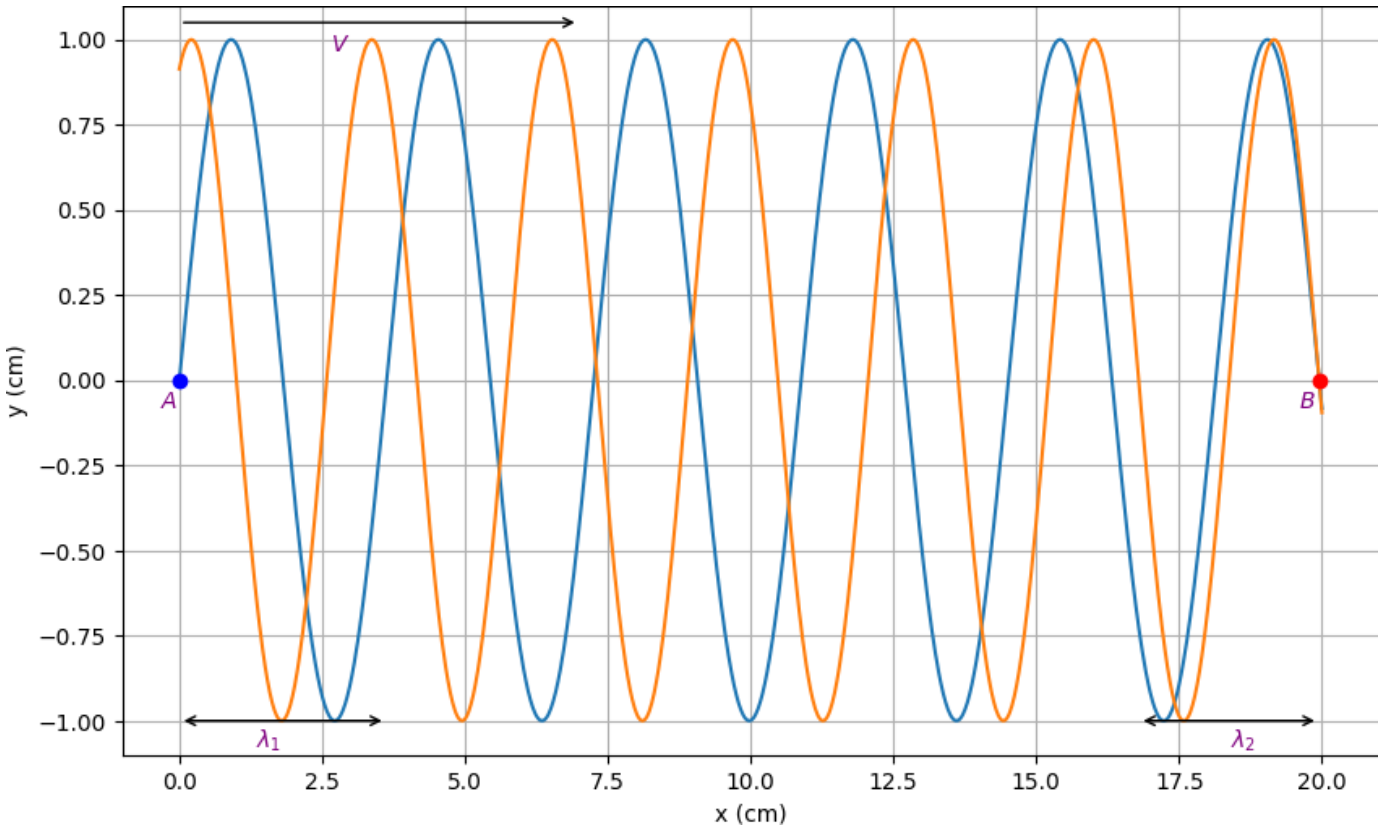

Fig. 0. Graph of SONAR and reflected waves

A : SONAR submarine
B : Enemy submarine
Blue graph : SONAR wave
Orange graph : Reflected wave