

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
V_{rel}	Relative velocity between both submarine	1550m/s
f	Frequency of SONAR wave	40kHz
$y(x, t)$	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
$y_2(x, t)$	Equation of reflected wave as observed from submarine	$A \sin\left(2\pi f''t - \frac{2\pi}{\lambda_2}x + \phi\right)$

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

$$V_{rel} = V + V_e \quad (1)$$

$$f' = V_{rel}/\lambda \quad (2)$$

$$= \left(\frac{V + V_e}{V}\right)f \quad (3)$$

$$= \left(\frac{1450 + 100}{1450}\right)40 \quad (4)$$

$$= 42.76kHz \quad (5)$$

$$\lambda_2 = T(V - V_e) \quad (6)$$

$$= \left(\frac{V - V_e}{f'}\right) \quad (7)$$

$$f'' = V/\lambda_2 \quad (8)$$

$$= \left(\frac{V}{V - V_e}\right)f' \quad (9)$$

Parameter	Description	Value
$f'' = \left(\frac{V}{V - V_e}\right)f'$	Frequency of reflected wave	45.93kHz

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

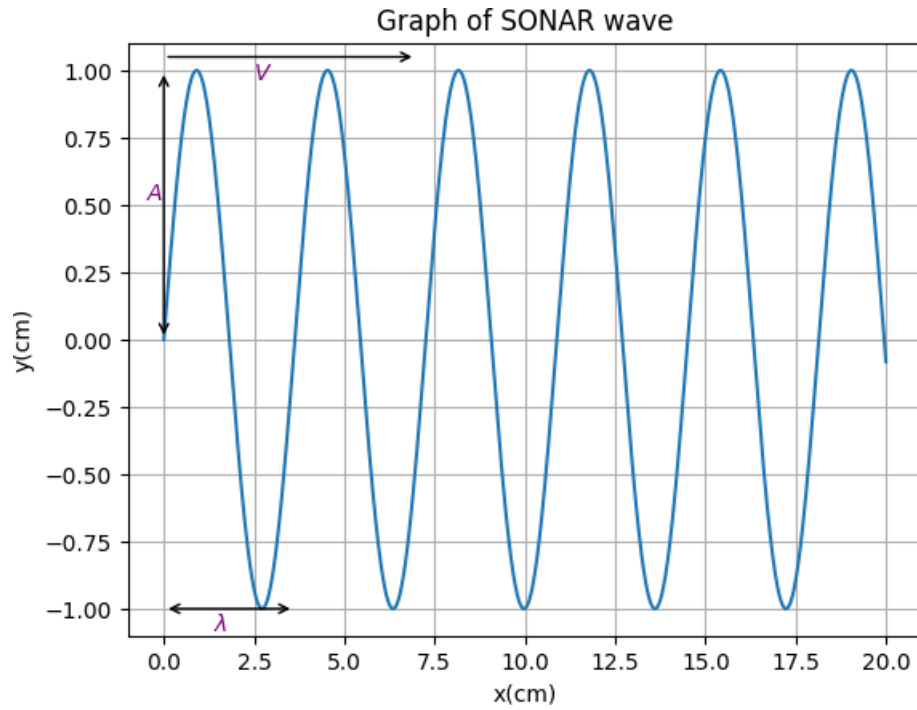


Fig. 1

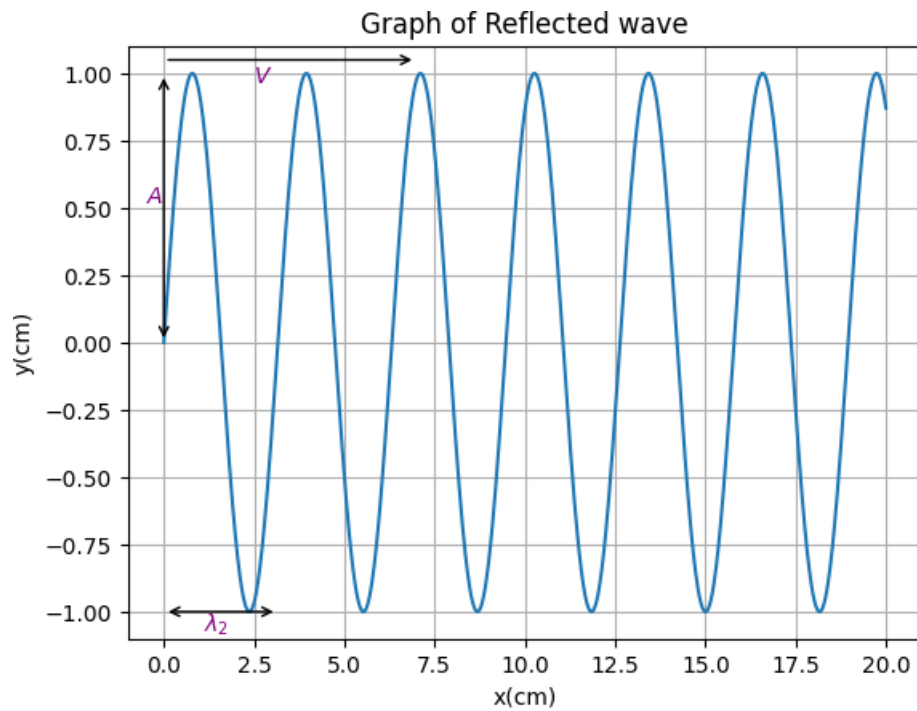


Fig. 2