Ex There are two tuning forks A and B That Produces 5 beats / sec. The frequency of A = 512. When B is filled, 5 beats / sec are again produced. Calculate the frequency of B before and after filling.

Sol Given that frequency of A = 512

Beats Per Second = 5

Frequency of B before filling will be either

$512 + 5 = 517$, or $512 - 5 = 507$

we know That, 5 beats / sec are generated again after filling, the frequency of B after filling is either.

$512 + 5 = 517$ or $512 - 5 = 507$

Consider the frequency of B before filling as 517. The frequency increases after filling. Therefore the frequency of B after filling cannot be equal to 517 or 507. Therefore, the frequency of B cannot be equal to 517.

Consider the frequency of B before filling 507. After filling its frequency can be equal to 517

These will be the Possible Value

So, frequency of B before filling = 507

after filling = 517

Thus, the frequency of B before filling is 507 and after filling is 517.

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Ex: A note produces 4 beats/sec with a tuning fork of frequency 512 and 6 beats/sec with a fork of frequency 514. Calculate the frequency of the note.

Sol ① Given that, frequency of the tuning fork = 512

Beats/sec = 4

Thus the possible frequencies of the note are given as

$$\left.\begin{matrix} 512+4 \\ 512-4 \end{matrix} = \begin{matrix} 516 \\ 508 \end{matrix}\right] \text{—— ①}$$

② Given that, frequency of the tuning fork = 514

Beats / second = 6

Thus the possible frequencies of the note are given as

$$\left.\begin{matrix} 514+6 \\ 512\cancel{+}6 \end{matrix} = \begin{matrix} 520 \\ 508 \end{matrix}\right] \text{—— ②}$$

The common frequency in equ^n ① and equ^n ② is 508. Therefore the frequency of the note is 508.

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Equation of Beats

Suppose there are two wave trains having frequency n_1 and n_2 where $(n_1 - n_2)$ is small. Assume that a and b are the amplitudes of the waves respectively. Simply, we can assume that the two waves are in phase at any point in the medium at $t=0$. The displacement y_1 and y_2 due to each wave are specified as

$$y_1 = a \sin \omega_1 t$$

$$y_2 = b \sin \omega_2 t$$

Here $\omega_1 = 2\pi n_1$

and $\omega_2 = 2\pi n_2$

$$\therefore \quad y_1 = a \sin 2\pi n_1 t \quad \text{---} \quad (1)$$

and $$y_2 = b \sin 2\pi n_2 t \quad \text{---} \quad (2)$$

The resultant displacement is specified as

$$y = y_1 + y_2$$

$$y = a \sin 2\pi n_1 t + b \sin 2\pi n_2 t$$

$$y = a \sin 2\pi n_1 t + b \sin 2\pi [n_1 - (n_1 - n_2)] t$$

$$y = a \sin 2\pi n_1 t + b [\sin 2\pi n_1 t \cos 2\pi (n_1 - n_2) t - \cos 2\pi n_1 t \sin 2\pi (n_1 - n_2) t] \quad \text{---} \quad (3)$$

$$y = \sin 2\pi n_1 t [a + b \cos 2\pi (n_1 - n_2) t - \cos(2\pi n_1 t) [b \sin 2\pi (n_1 - n_2) t]$$

Take $a + b \cos 2\pi (n_1 - n_2) t = A \cos \theta$

And $b \sin 2\pi (n_1 - n_2) t = A \sin \theta$

$$\therefore \quad y = A \sin (2\pi n_1 t - \theta)$$

Here $\tan\theta = \dfrac{b \sin 2\pi(n_1 - n_2)t}{a + b\cos 2\pi(n_1 - n_2)t}$ — (4)

and

$$A = \sqrt{a^2 + b^2 + 2ab\cos 2\pi(n_1 - n_2)t} \quad \text{— (5)}$$

Equation (4) specifies that the phase angle θ changes with respect to time. Similarly equⁿ (5) specifies that the amplitude of the resultant vibration also changes with time.

1.) When $2\pi(n_1 - n_2)t = 2k\pi$
where $k = 0, 1, 2, 3, \ldots$ etc.
The resultant amplitude

$$A = \sqrt{a^2 + b^2 + 2ab}$$

$$A = (a+b) \longrightarrow (6)$$

If $t = \dfrac{k}{(n_1 - n_2)}$, The resultant amplitude is defined as maximum.

~~If $t = \frac{k}{(n_1}$~~

i.e. at time instant, $0, \dfrac{1}{(n_1 - n_2)}, \dfrac{2}{(n_1 - n_2)}$ etc. the amplitude of the resultant is maximum. The maximum sound intensity will be audible during the such instants since sound intensity is directly proportional to the square of amplitude.

$0, \frac{1}{(n_1-n_2)}, \frac{2}{(n_1-n_2)}, \frac{3}{(n_1-n_2)}, \ldots$ etc.

2.) When $2\pi(n_1-n_2)t = (2k+1)\pi$
where $k = 0, 1, 2, 3,$ etc.
The resultant amplitude $A = \sqrt{a^2+b^2-2ab}$
$A = (a-b)$
If $t = \frac{(2k+1)}{2(n_1-n_2)}$, the resultant amplitude is defined as maximum that means at time instants.

$\frac{1}{2(n_1-n_2)}, \frac{3}{2(n_1-n_2)}, \frac{5}{2(n_1-n_2)}, \ldots$ etc.

The amplitude of the resultant is minimum.
Since the minimum intensity of second will be heard at the instant, so

$\frac{1}{2(n_1-n_2)}, \frac{3}{2(n_1-n_2)}, \frac{5}{2(n_1-n_2)}, \ldots$ etc.

Hence, the maxima and minima occur alternately after equal intervals of time

$\frac{1}{2(n_1-n_2)}$.

The time interval between two Successive maxima <u>or</u> between two Successive minima is

$$\frac{1}{(n_1 - n_2)}$$

We Know That The Number of beats Produced Per Second is $(n_1 - n_2)$. In Case The amplitude of The two wave trains are equal, The maximum resultant amplitude is 2a and The minimum amplitude is 0. Here, The intensity of minima Positions will be Zero.