



13. A train is moving on a straight track with speed  $20 \text{ ms}^{-1}$ . It is blowing its whistle at the frequency of  $1000 \text{ Hz}$ . The percentage change in the frequency heard by a person standing near the track as the train passes him is (speed of sound =  $320 \text{ ms}^{-1}$ ) close to:

- (1) 6%                                      (2) 12%                                      (3) 18%                                      (4) 24%

**Answer:** We know apparent frequency ( $n'$ ) is related to actual frequency ( $n$ ) by

$$n' = \frac{v \pm v_0}{v \pm v_s} n$$

Here  $v_0 = \text{velocity of the listener} = 0$

When train is approaching apparent frequency heard will be more hence denominator will be less

$$n' = \frac{v}{v - v_s} n$$

When train is going away, apparent frequency will be less hence

$$n'' = \frac{v}{v + v_s} n$$

Need to find  $\frac{n' - n''}{n} \times 100$

$$\frac{n' - n''}{n} \times 100 = \left( \frac{v}{v - v_s} - \frac{v}{v + v_s} \right) \times 100 = \frac{2vv_s}{(v - v_s)(v + v_s)} \times 100$$

$$= \frac{2 \times 320 \times 20}{300 \times 340} \times 100 = 12.54\% \approx 12\%$$

**Correct choice is option (2) 12%**