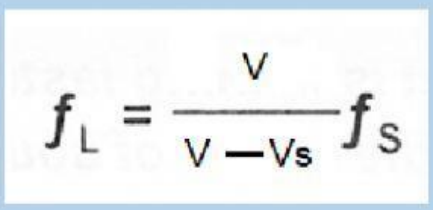
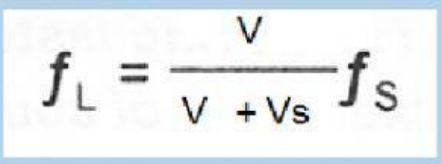
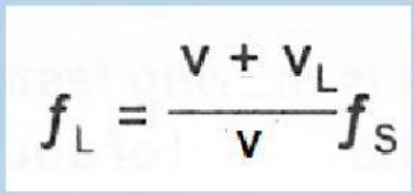
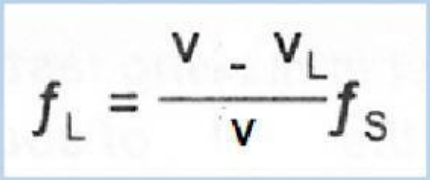
In summary

The observed (f_L)/the frequency heard by the listener will **increase** when:	The observed (f_L)/the frequency heard by the listener will decrease when:
The source is moving **towards** a stationary listener 	The source is moving **away from** a stationary listener 
The listener is moving **towards** a stationary source 	The listener is moving **away from** a stationary source 

*Notice that when you want the answer value to be large you need to do very different things depending on whether you are looking at the numerator or denominator.

Numerator – you will need to add the values at the top to get a big answer

Denominator – you will need to subtract the values at the bottom to get a big answer

Eg

Making the numerator bigger (while keeping the denominator constant)

$= \frac{4}{4} = 1$

$= \frac{6}{4} = 1{,}5$

Making the denominator bigger (while keeping the numerator constant)

$= \frac{4}{4} = 1$

$= \frac{4}{8} = 0{,}5$

Watch this little video quick to check your understanding

Calculations:

Question 1

Question: The siren of an ambulance has a frequency of 700 Hz. You are standing on the pavement. If the ambulance drives past you at a speed of 20 $m \cdot s^{-1}$, what frequency will you hear, when

a) the ambulance is approaching you

b) the ambulance is driving away from you

Take the speed of sound to be 340 $m \cdot s^{-1}$.

a)

$$\begin{aligned} f_s &= 700\text{Hz} \\ v &= 340\,\text{m} \cdot \text{s}^{-1} \\ v_L &= 0 \\ v_S &= 20\,\text{m} \cdot \text{s}^{-1} \text{ for (a)} \end{aligned}$$

$$f_L = \frac{v \pm v_L}{v \pm v_S} f_S$$

$$f_L = \frac{v + 0}{v - v_S} f_S$$

$$f_L = \frac{340 + 0}{340 - 20}(700)$$

$$f_L = \frac{340\,(700)}{340 - 20}$$

=

Instructions: write only the answers with

- 2 decimal places
- leave no spaces between the value and the unit
- use comma's

Take note:

The frequency heard by a stationary listener won't increase and increase and keep increasing. It would stay constant (but higher than 700 Hz) while it is moving towards the listener and it will be lower than 700 Hz as the listener moves away from the source. This is because the speed of the source or listener is constant as it moves towards/away, thus the frequency is higher/lower (but not constantly increasing/decreasing)

b)

$$f_L = \frac{v \pm v_L}{v \pm v_S} f_S$$

$$f_L = \frac{v + 0}{v + v_S} f_S$$

$$f_L = \frac{340 + 0}{340 + 20}(700)$$

$$f_L = \frac{340\ (700)}{340 + 20}$$

=

*Always double check if your answer makes sense- if the source is moving away from the stationary listener in 1(b), then the listener should hear a lower frequency. Is the answer lower than 700Hz?

If so, then you've probably done it right!

Question 2

Question: What is the frequency heard by a person driving at 15 $m \cdot s^{-1}$ toward a factory whistle that is blowing at a frequency of 800 Hz. Assume that the speed of sound is 340 $m \cdot s^{-1}$.

$$f_L = \frac{v \pm v_L}{v \pm v_S} f_S$$

$$f_L = \frac{v + v_L}{v + 0} f_S$$

$$= \frac{(340+15)(800)}{340+0}$$

=

*Always double check if your answer makes sense- if the listener is moving towards the stationary source, then the listener should hear a higher frequency. Is the answer higher than 800Hz?

If so, then you've probably done it right!

Question 3

A girl is running away from a stationary train with a speed of 5m.s^{-1}, while its whistle is blowing at a frequency of 530 Hz. Calculate the frequency of the sound heard by the girl, as she is running away from the train.

$$f_L = \frac{v \pm v_L}{v \pm v_S} f_S$$

$$f_L = \frac{v - v_L}{v + 0} f_S$$

$$= \frac{(340-5)(530)}{340+0}$$

=

Question 4

A police car travels at a speed of 20 $m.s^{-1}$ towards a boy standing on a sidewalk. The frequency produced by the police siren is 400 Hz. Calculate the frequency heard by the boy on the sidewalk.

f_L =

Question 5

An ambulance with its siren on produces a sound with a frequency of 450Hz. The ambulance passes a stationary listener while travelling a speed of 25$m.s^{-1}$. Calculate the observed frequency of the siren as it moves away from the listener.

f_L =

Question 6

A girl is running away from a stationary train with a speed of $10 m.s^{-1}$, while its whistle is blowing at an unknown frequency. Calculate the frequency of the whistle if the frequency heard by the girl is 400Hz.

$$f_L = \frac{v \pm v_L}{v \pm v_S} f_S$$

$$f_L = \frac{v - v_L}{v + 0} f_S$$

$$\frac{400}{1} = \frac{340 - 10\ (fs)}{340}$$

**cross multiply*

400(340) = 330(fs)

136000 = 330fs

**divide both sides by 330*

fs =

Question 7

An ambulance with its siren on produces a sound with a frequency of 450Hz. The ambulance moves relative to a stationary listener while travelling at an unknown speed. Calculate the speed at which the ambulance travels if the observed frequency is 490Hz.

*notice they don't tell you whether the source is moving towards or away from the listener. But from the values we can figure it out. If the "real" frequency, or frequency made by the source is 450 Hz, but the frequency heard by the listener is 490Hz.Thus the ambulance must be moving **towards** the listener.

$$f_L = \frac{v \pm v_L}{v \pm v_S} f_S$$

$$\frac{490}{1} = \frac{340+0\ (450)}{340-vs}$$

$490(340 - v_s) = 340\ (450)$

**distributive law first*

$166600 - 490vs = 153000$

$166600 - 153000 = 490vs$

$13600 = 490v_s$

**divide both sides by 490*

$v_s =$ $m.s^{-1}$