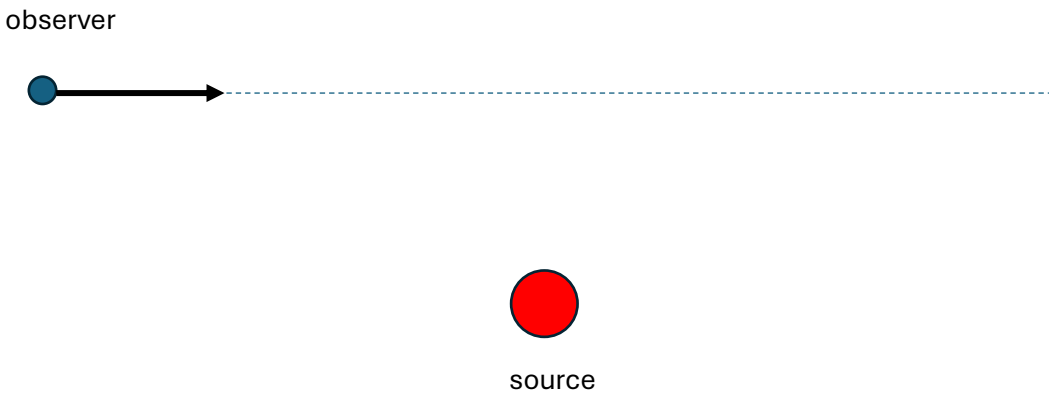
Teacher notes
Topic C

Two Doppler effect problems

1. A source emits sound of frequency 1000 Hz in all directions. An observer moves along the dotted line at a speed that is one tenth of the speed of sound.

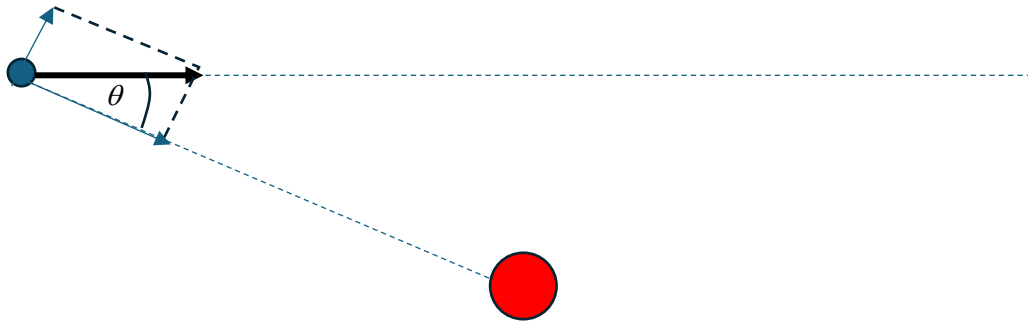
   What frequencies does the observer hear?



As the observer gets closer to the source the frequency will increase and as the observer moves away the frequency will decrease. We have to use the formula for the moving observer Doppler effect which is $f = f_0 \frac{c+v}{c}$ as the observer approaches and $f = f_0 \frac{c-v}{c}$ as the observer recedes.

However, what is *v*?

The speed that goes into the Doppler formulae **is the component of velocity along the line of sight**. We take components of the velocity along the line of sight and along a direction normal to it. The relevant component is then $v\cos\theta$ as seen in the figure below.



When the observer is very far away on the left $\theta = 0$ and when it is very far away on the other side it is $\theta = \pi$. This means that the magnitude of the velocity component along the line of sight in both cases will be *v*.

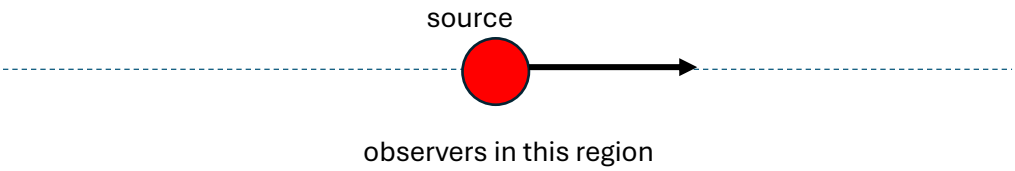
Hence the observer will hear frequencies **in the range**

$$f = f_0 \frac{c+v}{c} = 1000 \times \frac{1.1c}{c} = 1100 \text{ Hz}$$

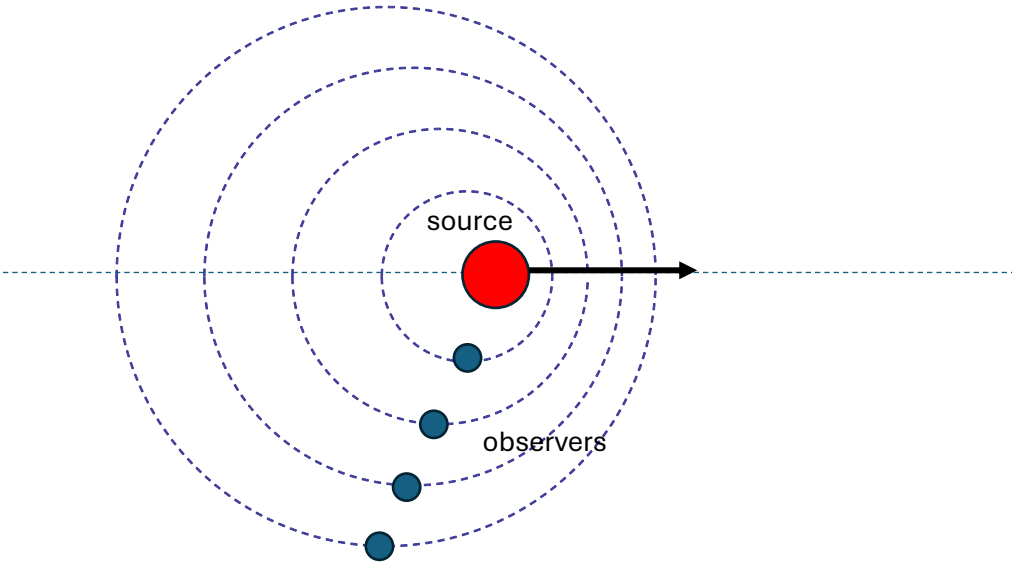
to

$$f = f_0 \frac{c-v}{c} = 1000 \times \frac{0.90c}{c} = 900 \text{ Hz}$$

2. We now have a moving source along the dotted line and several stationary observers are below the line. When the source is in the position shown where should the observers be, so that they hear the same frequency as that emitted by the source.



The diagram shows four wavefronts emitted by the source. When each wavefront was emitted the source was at the center of that wavefront.



For the observer to measure the same frequency as the source the wavefronts must arrive at the observer as shown. This is because at these positions, there was no relative velocity between source and observer (remember the source was at the center of the wavefront when it was emitted).

PS. In problem 1, at what position does the observer hear the same frequency as that emitted by the source|?