Name: ______________________

Class: ______________________

Due Date: ______________________

Physics Topic 40 – Doppler Effect

Answer the following questions. The solutions to this worksheet can be found on the YouTube channel Go Physics Go.

1. C: Define the *Doppler effect*.

2. C: **Use a pencil!** Draw a wavefront diagram for a moving source and stationary observer in front of the source and behind the source.

3. C: Fill in the blanks: A car travels to the right with a constant speed and emits a constant sound with a constant frequency. The car moves away from observer 1 and towards observer 2. Observer 1 will detect a ___________ wavelength and a ___________ frequency as compared to the source. Observer 2 will detect a ___________ wavelength and an ___________ frequency as compared to the source. The speed of sound measured by observer 1 will be ___________ the speed of sound measured by observer 2 since the sound wave travels in the same medium.

4. C: **Use a pencil!** Draw a wavefront diagram for a stationary source and moving observer moving with a constant speed in front of the source and behind the source.

5. C: Describe the equation $\frac{\Delta f}{f} = \frac{\Delta \lambda}{\lambda} \approx \frac{v}{c}$ and define each variable.

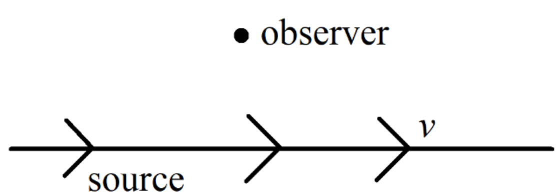
6. C: Describe the term *red shift*.

7. C: Describe the term *blue shift*.

8. C: Describe the term *expanding universe*.

9. C: A train approaches and then passes a train station with **a constant speed**. During the whole time the train is emitting a sound. Draw a *frequency vs. time* graph of the observed frequency measured by the observer at the train station.

10. C: A train approaches and then passes a train station with **a constant speed**. During the whole time the train is emitting a sound. An observer is outside of the train station as seen in the image below. Draw a *frequency vs. time* graph of the observed frequency measured by the observer outside of the train station.



11.C: **An accelerating train** approaches and then passes a train station. During the whole time the train is emitting a sound. Draw a *frequency vs. time* graph of the observed frequency measured by an observer at the train station.

12.C: **A decelerating train** approaches and then passes a train station. During the whole time the train is emitting a sound. Draw a *frequency vs. time* graph of the observed frequency measured by an observer at the train station.

13.C: List some practical uses for the Doppler effect.

14.E: An element on Earth emits a spectral line which has a wavelength of 600 nm as measured by an Earth observer. Calculate the wavelength of the same spectral line if it is observed from a galaxy moving **away from the Earth** with a speed of $0.2c$.

15.E: An element on Earth emits a spectral line which has a wavelength of 600 nm as measured by an Earth observer. Calculate the wavelength of the same spectral line if it is observed from a galaxy moving **towards the Earth** with a speed of $0.2c$.

16.E: An element on Earth has one emission wavelength of 8.67×10^{-7} m. This same element, when detected from a moving distant galaxy, has the same emission wavelength of 3.09×10^{-7} m.

a. Is this galaxy moving towards or away from Earth?

b. What is the speed of this moving galaxy?

17.E: This is the classic "the emitter becomes the detector" problem! A stationary police car emits a microwave with a frequency of 3.00×10^{10} Hz to an approaching car. The microwave is reflected off the moving car and is received by the stationary police car. The police car detects that the frequency is altered by 6.00×10^{3} Hz.

a. What is the wavelength of the microwave being emitted by the police car?

b. What is the speed of the approaching car?

c. How much has the wavelength altered?

18.C: Describe the equations for the Doppler effect.

19.E: Late to class! Usain Bolt runs towards his physics class with a constant speed of 10.44 m/s while blasting music from his boom box which emits a frequency of 440. Hz. What is the observed frequency and wavelength detected by the students in his physics classroom? The speed of sound in air at sea level is approximately 340.29 m/s.

20.E: Class ends! Usain Bolt runs away from his physics class towards the cafeteria with a constant speed of 10.44 m/s while blasting music from his boom box which emits a frequency of 440. Hz. What is the observed frequency and wavelength detected by the students in his physics classroom? The speed of sound in air at sea level is approximately 340.29 m/s.

21.E: Late to class! Usain Bolt runs towards his physics class with a constant speed of 10.44 m/s. He can hear his physics teacher lecturing with frequency of 440. Hz. What is the observed frequency and wavelength detected by Usain Bolt as he is running towards his physics class? The speed of sound in air at sea level is approximately 340.29 m/s.

22.E: Class ends! Usain Bolt runs away from his physics class to the cafeteria with a constant speed of 10.44 m/s. He can hear his teacher continue to lecture with frequency of 440. Hz. What is the observed frequency and wavelength detected by Usain Bolt as he is running towards the cafeteria? The speed of sound in air at sea level is approximately 340.29 m/s.

23.E: This is the classic "the emitter becomes the detector" problem! An emitter at rest emits a sound wave of frequency 3.00×10^4 Hz towards a car. The wave is reflected back to the emitter. The emitter now becomes the receiver. The receiver receives the sound wave with a frequency of 2.90×10^4 Hz. The speed of sound is $3.30 \times 10^2\ \frac{\text{m}}{\text{s}}$. Determine the speed of the car.

24.E: This is another classic "the emitter becomes the detector" problem! An emitter at rest emits a sound wave of frequency 3.00×10^4 Hz towards a car. The wave is reflected back to the emitter. The emitter now becomes the receiver. The receiver receives the sound wave with a frequency of 3.10×10^4 Hz. The speed of sound is $3.30 \times 10^2\ \frac{\text{m}}{\text{s}}$. Determine the speed of the car.