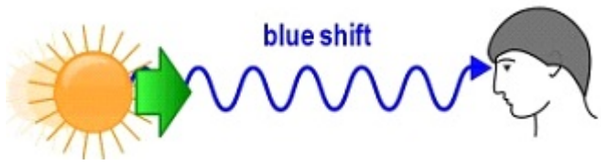
PHYSICS 2204
Unit 4: Waves
Worksheet #10: Doppler Effect and Electromagnetic Radiation

Student Name: _____

Doppler Effect is the change in frequency (and wavelength) of light, caused by the relative motion of the source and the observer

- If light is travelling as a wave with a certain frequency, it too can experience the doppler effect - If light is coming from a moving source (or if the viewer is moving), the light will experience the Doppler Effect.
- So, the viewer would observe the light at a different frequency(color) than the source.
- If the light is perceived as a different frequency, it would appear as a different colour.
- Light moving away from the observer – Wavelength gets longer: REDSHIFT

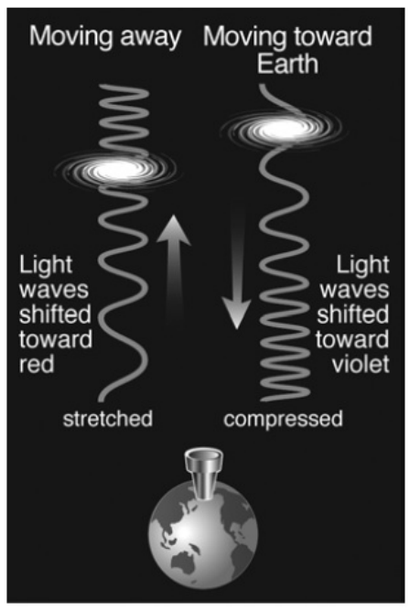
- Light moving towards the observer - Wavelength gets shorter: BLUESHIFT



The Doppler effect and Electromagnetic Radiation

The Doppler shift is also an important tool used by astronomers to study the motion of objects, such as stars and galaxies, in space. For example, if an object is moving toward Earth, the light waves it emits are compressed, shifting them toward the blue end (shorter wavelengths, higher frequencies) of the visible spectrum. If an object is moving away from Earth, the light waves it emits are stretched, shifting them toward the red end (longer wavelengths, lower frequencies) of the visible spectrum. In this skill sheet, you will practice solving problems that involve light and doppler shift.

Understanding Doppler shift



Astronomers use a spectrometer to determine which elements are found in stars and other objects in space. When burned, each element on the periodic table produces a characteristic set of spectral lines. When an object in space is moving very fast, its spectral lines show the characteristic patterns for the elements it contains. However, these lines are shifted.

If the object is moving away from Earth, its spectral lines are shifted toward the red end of the spectrum to a longer wavelength. If the object is moving toward Earth, its spectral lines are shifted toward the blue end of the spectrum to a shorter wavelength

Some other Applications of the Doppler Effect is :

-Radar Gun
-Doppler Weather Radar

When applying the Doppler effect to electromagnetic waves you only have the following formula:

$$v_r = \left(\frac{\Delta f}{2 f_1}\right) c$$

v_r is the relative speed of the object

Δf is the difference in frequency between the emitted ray and the received ray

f_1 is the emitted frequency

c is the speed of light

Example 1:

A stationary police officer on the side of highway points a radar gun at a speeding car coming towards him. If the gun emits electromagnetic waves at 9.0×10^9 Hz and detects waves differing by 2000 Hz from the original wave, what was the speed of the car?

Example 2:

A radar gun is used to clock the speed of a hockey puck at 108 km/hr. The radar gun emits wave frequency of 2.50 GHz. What is the change in frequency detected by the radar gun?

PART A: MULTIPLE CHOICE

Instructions: Shade the letter of the correct answer on the computer scorable answer sheet provided.

1. What best describes the Doppler Effect?

   (A) An apparent change in frequency of a wave due to the relative motion between a wave source and an observer
   (B) An apparent change in the amplitude of a wave due to the relative motion between a wave source and an observer.
   (C) When light changes color
   (D) When sound changes pitch

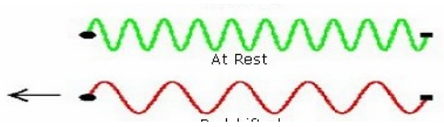
2. What kind of waves undergo Doppler Effect

(A) Sound waves
(B) Light Waves
(C) Both sound waves and light waves
(D) Neither sound waves or light waves

3. When a light source is quickly approaching you, you may perceive a

(A) Blue shift
(B) Pink shift
(C) Red Shift
(D) Violet Shift

4. What is shown in the picture below?



(A) Blue shift
(B) Pink shift
(C) Red Shift
(D) Violet Shift

5. When redshift occurs, What happens to the perceived frequency of the wave

(A) Decrease
(B) Increase
(C) Increase and Decrease
(D) Stay the same

6. When blueshift occurs, What happens to the perceived WAVELENGTH of the wave ?

(A) Decrease
(B) Increase
(C) Increase and Decrease
(D) Stay the same

7. Which of the following is an application of the Doppler Effect?

(A) Radar gun
(B) TV remote
(C) Ultrasound
(D) X Ray

8. A police officer uses a radar gun that generates a microwave with frequency of 36.0 GHz. The stationary officer targets a car traveling directly toward him and measures a frequency shift of 4000 Hz. How fast is the car traveling?

(A) 16.6 m/s
(B) 33.3 m/s
(C) 75.0 m/s
(D) 96 m/s

9. A radar gun can determine the speed of a moving automobile by measuring the difference in frequency between emitted and reflected radar waves. What process does this illustrate?

(A) Diffraction
(B) Doppler effect
(C) Refraction
(D) Resonance

10. The same officer targets a car traveling at a 20^{o} angle with respect to the line of sight. A frequency shift of 1500Hz is recorded for the vehicle. How fast is the car traveling toward the officer?

(A) 6.25 m/s
(B) 12.5 m/s
(C) 16.6 m/s
(D) 33.3 m/s

11. A police radar sends microwaves with a 20 GHz frequency towards a car. The frequency of the reflected wave received by the radar is 5000 Hz greater than the frequency of the emitted wave. What is the speed of the vehicle?

(A) 67.5 km/hr
(B) 100. km/hr
(C) 135 km/hr
(D) 270 km/hr

12. A radar gun was used to clock the speed of a baseball at 153 km/hr. The radar gun emits wave frequency of 25.0×10^{9}Hz. What is the change in frequency detected by the radar gun?

(A) 3.54 K Hz
(B) 7.08 KHz
(C) 4.59×10^{4} Hz
(D) 9.18×10^{4} Hz

PART B: WRITTEN RESPONSE

1. (A) An ordinary light bulb gives off visible white light. If you were moving toward it at nearly the speed of light, it would appear to be emitting X rays, while if you moving away from it at the same high speed, it would appear to be emitting radio waves. This is an example of what wave phenomenon?

(B) In both cases you could not see the bulb's "light" with your eyes. Why?

2. Calculate the speed on an approaching car if it is detected using a stationary radar gun emitting waves of 9.2 Ghz and the rebounding wave is different by 2000 Hz.

3. What is the speed of a car detected by a radar gun with a frequency 7.8×10^{9} Hz if the difference in frequencies between emitted and received wavelength is 2000 Hz? Assume that the radar gun is stationary and the car is approaching it approximately head on.

4. How do police officers use the Doppler Effect to determine whether or not you deserve a ticket?