**ROYAL CANADIAN AIR CADETS**

**PROFICIENCY LEVEL FOUR**

**INSTRUCTIONAL GUIDE**

**SECTION 3**

# EO C429.03 – DESCRIBE RADIO WAVELENGTHS, SIGNALS, LICENCES AND EQUIPMENT

Total Time: 30 min

## PREPARATION

### PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-804/PG-001, *Proficiency Level Four Qualification Standard and Plan*, Chapter 4. Specific uses for said resources are identified throughout the instructional guide within the TP for which they are required.

Review the lesson content and become familiar with the material prior to delivering the lesson.

Photocopy the handouts located at Attachments A and C for each cadet.

Prepare slides located at Attachments B and D.

### PRE-LESSON ASSIGNMENT

Nil.

### APPROACH

An interactive lecture was chosen for this lesson to orient the cadets to the topic of radio wavelengths, signals, licences, and equipment and to create interest in the subject.

## INTRODUCTION

### REVIEW

Nil.

### OBJECTIVES

By the end of this lesson the cadet shall describe radio wavelengths, signals, licences and equipment.

### IMPORTANCE

It is important for cadets to describe radio wavelengths, signals, licences and equipment as it helps them to better understand radio theory and licencing procedures. This information is required knowledge for the Industry Canada Restricted Operator Certificate with Aeronautical Qualification (ROC-A).



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**Teaching point 1** **Describe radio wavelengths, frequencies and bands.**

Time: 5 min Method: Interactive Lecture

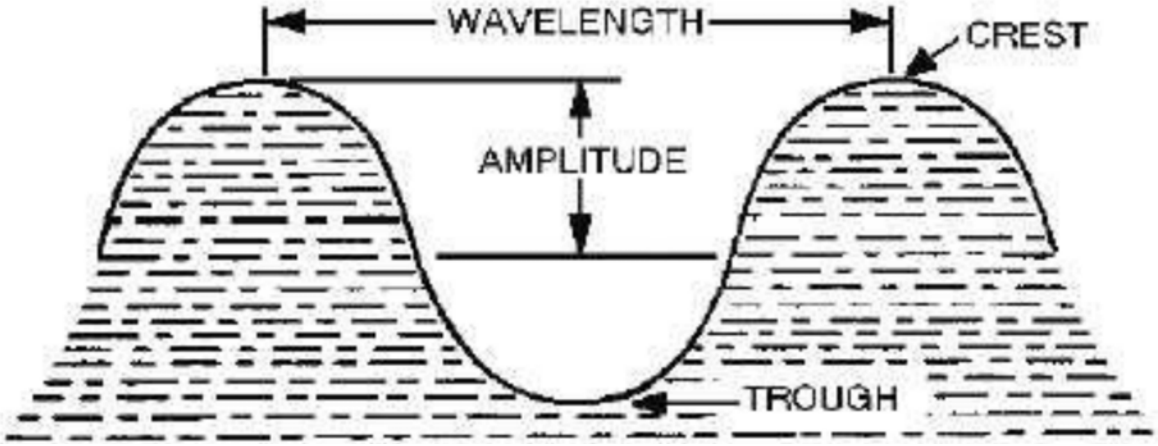
Distribute the handout located at Attachment A to each cadet. Cadets will label the handout as the information is presented.

**CYCLE**

Show the slide of Figure B-1 to the cadets.

When a pebble is dropped into water, waves are made. The waves decrease in height or strength as they travel away from the point of origin. The lengths of the waves never vary.

A radio transmitter sends out waves known as wavelengths. The linear measurement of the wave is measured in metres (m). A wavelength is the distance between two successive crests or two successive troughs.




*Note. From Integrated Publishing, Transverse Wave. Retrieved October 31, 2008, from http://www.tpub.com/content/neets/14182/css/14182_17.htm*

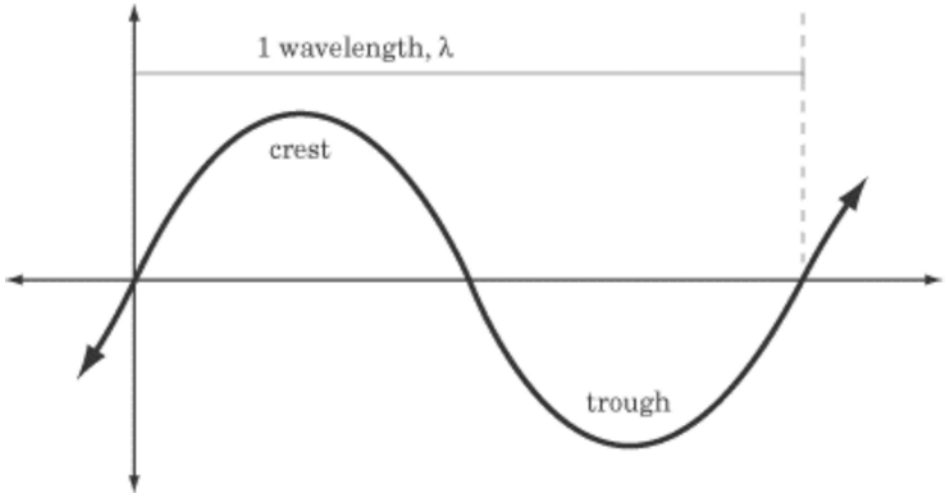
Figure 1 Wavelength

Show the slide of Figure B-2 to the cadets.

Every crest (highest part of the wave) is separated by a trough (lowest part of the wave) to create an alternating pattern of crests and troughs known as cycles. A cycle is the period of time in which the wave vibrates up and down.



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Verify against the official publication.




*Note. From "SparkNotes", 2006, Crests, Troughs, and Wavelength. Retrieved October 24, 2008, from http://sparknotes.com/testprep/books/sat2/physics/chapter17section2.rhtml*

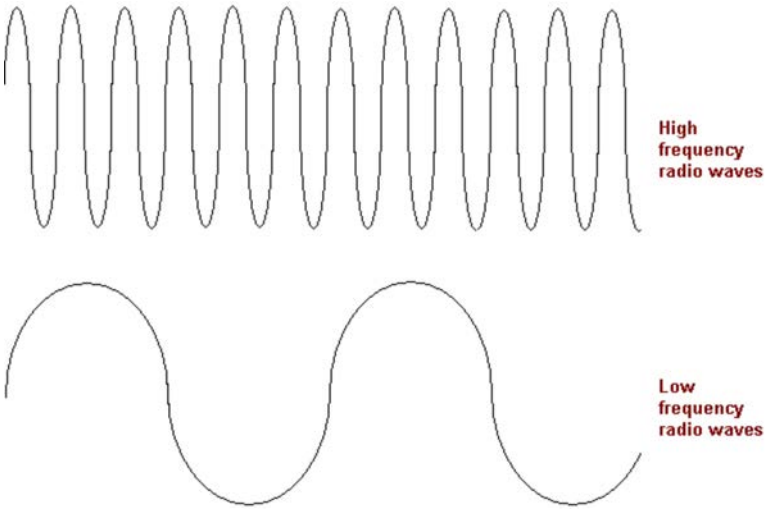
Figure 2 Crest and Trough

The number of cycles per second is called frequency. The unit for frequency is the Hertz (Hz) where one Hz is equivalent to one cycle per second.




Show the slide of Figure B-3 to the cadets.

The lowest frequencies have the longest radio waves and the highest frequencies have the shortest radio waves.




*Note. From "Communications System", What is Frequency? Retrieved October 24, 2008, from http://qrg.northwestern.edu/project/vss/docs/Communications/1-what-is-frequency.html*

Figure 3 Radio Wave Frequencies



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### KILOHERTZ

Very low to high frequencies are measured in kilohertz (kHz). kHz represents 1 000 waves passing a fixed point in one second.

### MEGAHERTZ

Very high frequencies are measured in megahertz (MHz). MHz represents 1 000 kHz or 1 000 000 Hz passing a fixed point in one second.




The relationship between Hz, kHz and MHz can be explained as 1 000 000 Hz = 1 000 kHz = 1 MHz

### LOW, MEDIUM, VERY HIGH, AND ULTRA HIGH FREQUENCY BANDS

Radio waves use the electromagnetic spectrum. The spectrum is divided into a number of frequency bands each possessing characteristics that determine the usage. Industry Canada, on behalf of the World Radio Communication Conference (WRC), allocates specific frequency bands to service domestic communication requirements.

Aviation radio communication facilities and radio navigation aids operate in different bands including:

- low frequency (LF),
- medium frequency (MF),
- high frequency (HF),
- very high frequency (VHF), and
- ultra high frequency (UHF).

#### Low Frequency (LF) Band

Non-directional and marker beacons transmit navigational signals as well as some voice transmissions in the 200–415 and 510–535 kHz band.

#### Medium Frequency (MF) Band

Commercial broadcasts can be used for directional bearings with automatic direction finding equipment in the 550–1 750 kHz band.

#### High Frequency (HF) Band

High frequencies are allocated in 100 kHz increments between 2 500–30 000 kHz. Numerous HF frequencies have been given to aviation. HF is excellent for air / ground communication. HF radio is the only way to maintain constant contact at ranges of 4 023 kilometres or more on transoceanic flights.

HF signals can be unpredictable, being affected by the day and night variations of the ionosphere as well as sunspots, auroras, etc.

HF stations in the upper range of HF bands get greater reception distance during daylight hours. Stations in the lower range get greater reception distance during the night.



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Remember the mnemonic:

- sun up, frequency up, and
- sun down, frequency down.

**Very High Frequency (VHF) Band**

The most important band is between 30–300 MHz known as the VHF band. Certain ranges for frequencies have been allocated exclusively for aviation including:

- 108.00–117.98 MHz for navigational stations,
  - VHF omnidirectional range (VOR) stations,
  - instrument landing systems (ILS), and
  - voice reception;
- 118.00–136.00 MHz is allocated for civilian aviation voice communication, and
- 136.00–136.975 MHz is allocated for civilian aviation used mostly for air carriers for en route communication.

The most common VHF frequencies include:

- 121.50 MHz—universal VHF emergency,
- 122.20 MHz—flight service stations in Canada for both transmitting and receiving,
- 122.350–122.700 MHz—private advisory stations transmit and receive,
- 122.800 MHz—universal communications (UNICOM) facility is an air-to-ground communication facility operated by a private agency to provide private advisory station (PAS) service at uncontrolled airports,
- 122.90 MHz—used by aircraft engaged in various private aeronautical activities, such as:
  - parachute jumping,
  - aerial crop spraying, and
  - formation flying;
- 123.400 MHz—used for soaring activities, and
- 126.70 MHz—for transmitting position reports and general communication with a flight service station in uncontrolled airspace.

**Ultra High Frequency (UHF) Band**

Except for the glide slope portion of the instrument landing system (ILS) and distance measuring equipment (DME), the frequencies lying between 300–3 000 MHz are allocated for government use.

**FREQUENCY ALLOCATION**



With the numerous VHF channels in use and with changes occurring continuously, it is advisable to state the frequency on which the call is being made to any airway communication station, control tower or other facility.



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VHF channels have been allotted for various aeronautical facilities under the Frequency Utilization Plan. Changes to the plan are made from time to time and published in Transport Canada (TC) Information Circulars.

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**CONFIRMATION OF TEACHING POINT 1**

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**QUESTIONS**:

Q1. What is a cycle?

Q2. What does one Hz equal?

Q3. Airway radio communication facilities and radio navigation aids operate in what bands?

**ANTICIPATED ANSWERS**:

A1. A cycle is the period of time in which the wave vibrates up and down.

A2. One Hz equals one cycle per second.

A3. Airway radio communication facilities and radio navigation aids operate in different bands including:

- low frequency (LF),
- medium frequency (MF),
- high frequency (HF),
- very high frequency (VHF), and
- ultra high frequency (UHF).

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**Teaching point 2** **Describe characteristics of radio signals.**

Time: 5 min Method: Interactive Lecture

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Radio waves travel both along the Earth and into the atmosphere. Each has characteristics that assist the transmission of the radio signal. Ground waves (surface waves) travel along the contour of the Earth by diffraction. Sky waves (spaces waves) can travel through the air directly to the receiving antenna or can be reflected from the ionosphere.




Distribute the handout located at Attachment C to each cadet. Cadets will label the handout as the information is presented.

**Ground Waves**



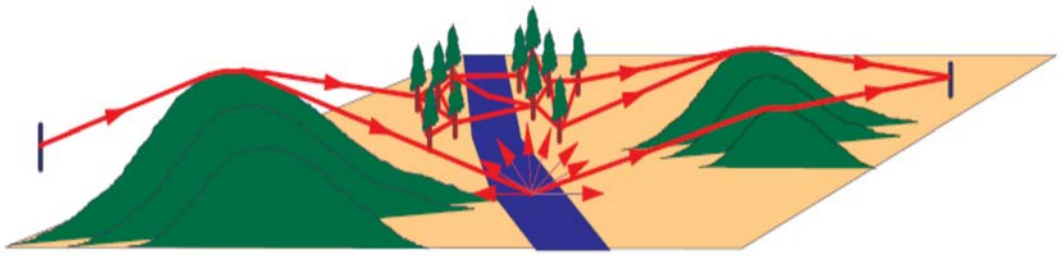

Show the slide of Figure D-1 to the cadets.

Ground waves travel by following the contours of the Earth. Travelling in straight lines, the wave will bend or curve, known as diffraction, around objects. As part of the ground wave comes in contact with the surface, it



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loses some of its energy, weakening or attenuating the ground wave. This loss of energy causes a downward tilt which helps the wave follow the Earth's curvature.



*Note. From Radio Wave Diffraction and Scattering Models for Wireless Channel Simulation (p. 5), by M. Casciato, 2001, Michigan: USA. Copyright 2001 by M. Casciato. Retrieved October 31, 2008, from http://www.eecs.umich.edu/RADLAB/html/NEWDISS/Casciato.pdf*

Figure 4 Ground Wave Transmission

Attenuation of the wave is affected by the nature of the surface. A radio wave will travel further over water, especially salty water, than land. Sand and ice cause poor conductivity compared to rich agricultural or marshy soil. Ground waves work best at lower frequencies.

**Sky Waves**



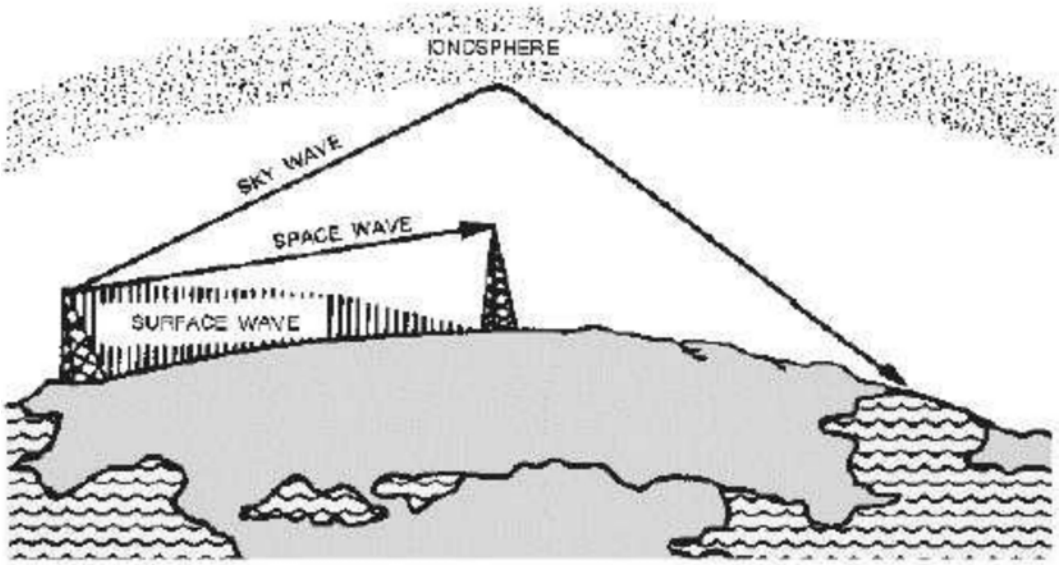

Show the slide of Figure D-2 to the cadets.

Transmission beyond the line of sight is possible through sky waves. Sky waves are radio waves that propagate into the atmosphere and bend back to the Earth from the ionosphere at some distance from the transmitter. Long-range communication is the result of sky wave transmission.

Two factors determine sky wave propagation: radio frequency and the level of ionization. Transmission of low, medium and high frequency radio waves vary by night and day. Sky waves travel at a flatter angle during the night. Sunspot activity or electromagnetic disturbances usually means more ionization of the ionosphere. HF communication is enhanced during times of greater sunspot activity.



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Verify against the official publication.




*Note. From "Integrated Publishing", Radio Wave Transmission. Retrieved October 31, 2008, from http://www.tpub.com/content/neets/14182/css/14182_75.htm*

Figure 5 Sky Wave Transmission

**CONFIRMATION OF TEACHING POINT 2**

**QUESTIONS**:

Q1. What do ground waves follow?

Q2. What is attenuation?

Q3. From where does a sky wave reflect back to the Earth?

**ANTICIPATED ANSWERS**:

A1. The curvature of the Earth.

A2. The loss of energy when part of the ground wave comes in contact with the surface.

A3. The ionosphere.

**Teaching point 3** **Describe aeronautical terms and definitions.**

Time: 5 min Method: Interactive Lecture

**AERONAUTICAL TERMS AND DEFINITIONS**

**Aerodrome.** Defined as any area, land or water, including any building, installations, and equipment used for the arrival or departure, movement, and servicing of aircraft.

**Aeronautical service.** A radio communication service that provides for the safety, navigation, and other operations of an aircraft including the exchange of air-to-ground messages.

**Aircraft station.** A mobile station in the aeronautical service other than a survival craft, located on board an aircraft.



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**Aeronautical Operation Control Communications (AOCC).** Communications related to the regularity of flight.

**Aeronautical station.** Location on land, on board a ship, or on a platform at sea receiving an aeronautical service. An aeronautical station may be as simple as a hand-held radio.

**Air Traffic Control (ATC) Service.** A service provided for the purpose of:

- preventing collisions between:
  - aircraft,
  - aircraft and obstructions, and
  - aircraft and vehicles on the manoeuvring area; and
- expediting and maintaining an orderly flow of air traffic.

**Controlled aerodrome.** An aerodrome at which an ATC service is provided.

**Flight Service Station (FSS).** A service providing mobile and fixed communications, airport advisory service (AAS), flight information, search and rescue alerting and weather and flight planning services to pilots and other users.

**General Aviation Communication (GAC).** Communication relating to all civil aviation operations other than for scheduled air service and non-scheduled air transport operations for hire, remuneration, or military aviation.

**Ground control communication.** ATC service communication provided for the purpose of:

- preventing collisions on the manoeuvring area between aircraft, aircraft and obstacles, or vehicles; and
- expediting and maintaining the orderly flow of aircraft operating on the manoeuvring area.

**Private advisory service.** A communication service offered at controlled aerodromes for use in connection with company business such as the servicing of aircraft, availability of fuel, lodging, etc.

**Private multiple station.** An aircraft or aeronautical station established to provide air-to-ground multi-purpose communication of an operational nature.

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**CONFIRMATION OF TEACHING POINT 3**

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**QUESTIONS**:

Q1. What is an aircraft station?

Q2. What is an aeronautical station?

Q3. What is a controlled aerodrome?

**ANTICIPATED ANSWERS**:

A1. A mobile station in the aeronautical service other than a survival craft located on board an aircraft.

A2. A station located on land, on board a ship or on a platform at sea. It may be as simple as a hand-held radio.

A3. An aerodrome at which an ATC service is provided.



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**Teaching point 4** **Describe radio station licences.**

Time: 5 min Method: Interactive Lecture

All radio stations in Canada must be licensed by Industry Canada. The licence specifies:

- call sign of the station,
- frequencies,
- special conditions,
- equipment, and
- fines.

**Call Sign of the Station**

A distinctive call sign is assigned to each radio station for identification purposes and should be used when initial contact is being established and again when the communication is concluded. Aeronautical call signs should always be pronounced phonetically.

**FREQUENCIES**

The license will specify frequencies to be used for transmitting. The use of the frequency for activities includes:

- air-to-air,
- air-to-ground instructional, and
- air-to-ground aerodrome traffic communications.

**Special Conditions**

Each station receives conditions for operation, including: the tower size, interference, and special services.

**EQUIPMENT**

All radio equipment used in aeronautical services is required to be licensed by Industry Canada.

**FINES**

Any person who establishes a radio station without a radio authorization is liable to a fine not exceeding $5 000, or imprisonment for a term not exceeding one year, or both.

A corporation may receive a fine not exceeding $25 000.

**CONFIRMATION OF TEACHING POINT 4**

**QUESTIONS**:

Q1. Why is a call sign assigned?

Q2. What does the licence specify about frequencies?

Q3. What is required for all radio equipment used in aeronautical services?



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**ANTICIPATED ANSWERS**:

A1. A call sign is assigned for identification.

A2. The licence specifies frequencies to be used for transmitting.

A3. All radio equipment used in aeronautical services is required to be licensed by Industry Canada.

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**Teaching point 5** **Describe maintenance of equipment.**

Time: 5 min Method: Interactive Lecture

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Avionics or radio equipment capable of two-way communication with ground stations or airborne stations include:

- a transceiver (transmitter and a receiver),
- a speaker (headset),
- a microphone, and
- antenna.

Equipment must be maintained and precautions need to be taken to ensure the serviceability of the avionics.

**Transceiver (transmitter and a receiver)**

A transmitter and a receiver are usually combined and called a transceiver. The transceiver should be warm but not hot to the touch. A cooling kit draws cool air from outside the airplane and pumps it around the equipment.

**Headset (speaker)**

The speaker(s) are included in the headset. The headset cables should not be knotted but coiled loosely when not being used.

**Microphone and Antenna Connections**

Microphone and antenna connections vary with the equipment. There should be no shorts or open wires when assembling connectors. Connections should be tight and clean. Where connections are exposed to the weather, they should be protected with a coating of silicone to prevent corrosion and to keep water from getting inside the outer casing of the cable.

**FUSES**

Electric circuits are protected against overload and short circuits by fuses, each rated for a given amperage. Fuses act as a safety valve. Fuses should never be replaced with one of a higher rating.

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**CONFIRMATION OF TEACHING POINT 5**

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**QUESTIONS**:

Q1. Why should radio equipment be maintained and precautions taken?

Q2. What precautions must be taken when assembling the microphone and antenna connections?

Q3. What is the function of a fuse?



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**ANTICIPATED ANSWERS**:

A1. To ensure serviceability of the avionics.

A2. Ensure there are no shorts or open wires are present.

A3. Protects electric circuits against overload and short circuits.

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**END OF LESSON CONFIRMATION**

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**QUESTIONS**:

Q1. Name the three parts of a wavelength.

Q2. What two factors determine sky wave propagation?

Q3. What does Flight Service Station (FSS) provide?

**ANTICIPATED ANSWERS**:

A1. A wavelength consists of:

- amplitude,
- trough, and
- crest.

A2. Radio frequency and the level of ionization.

A3. FSS provides service to pilots and other users including:

- mobile and fixed communication,
- airport advisory,
- flight information,
- search and rescue alerting,
- weather, and
- flight planning.

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**CONCLUSION**

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**HOMEWORK / READING / PRACTICE**

Nil.

**METHOD OF EVALUATION**

This EO is assessed IAW A-CR-CCP-804/PG-001*Proficiency Level Four Qualification Standard and Plan*, Chapter 3, Annex B, 429 PC.

**CLOSING STATEMENT**

Being able to describe radio wavelengths, signals, licences and equipment provides a better understanding of radio theory and licencing procedures. This knowledge is required to obtain the Industry Canada Restricted Operator Certificate with Aeronautical Qualification (ROC-A).



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**INSTRUCTOR NOTES / REMARKS**

If the squadron chooses to have cadets obtain the ROC-A, all complementary EOs for this PO must be instructed and a qualified examiner must conduct the 429 PC.

Cadets who are qualified Advanced Aviation may assist with this instruction.

## REFERENCES

C3-116 ISBN 0-9680390-5-7 MacDonald, A. F., & Peppler, I. L. (2000). *From the ground up: Millennium edition*. Ottawa, ON: Aviation Publishers Co. Limited.

C3-182 *Study guide for the radiotelephone operator's restricted certificate (Aeronautical)*. (2008). Retrieved September 28, 2008, from www.ic.gc.ca/epic/site/smt-gst.nsf/en/sf01397e.html

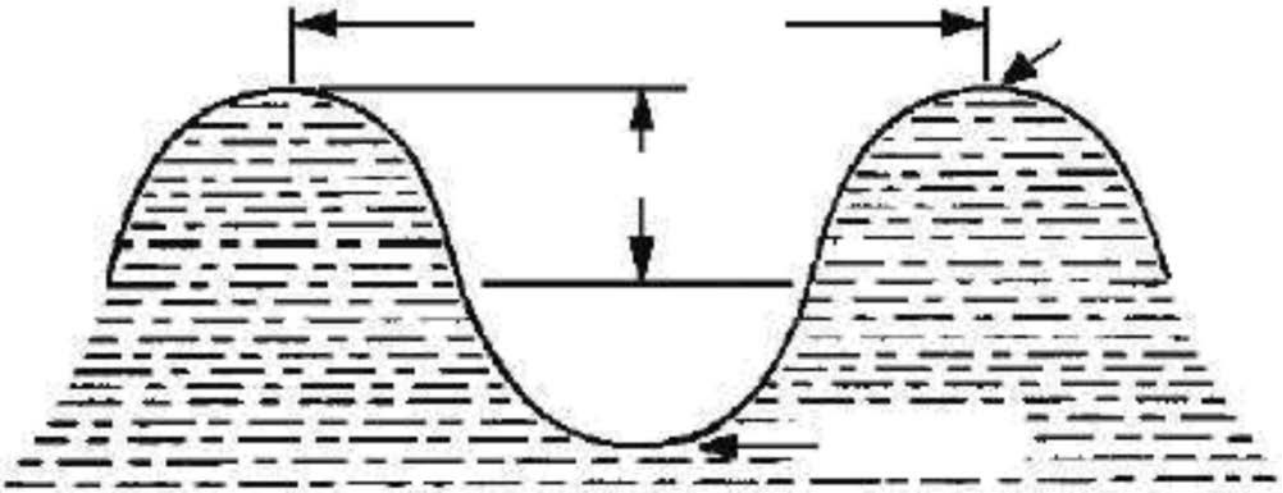


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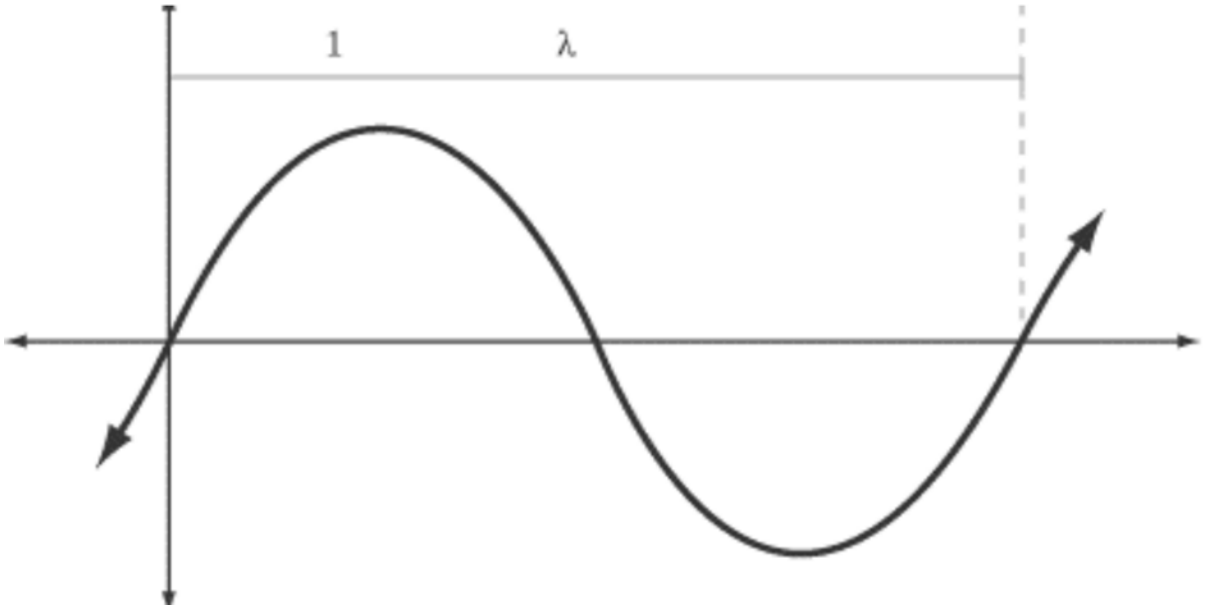


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*Note. From Integrated Publishing, Transverse Wave. Retrieved October 31, 2008, from http://www.tpub.com/content/neets/14182/css/14182_17.htm*

Figure A-1 Transverse Wavelength

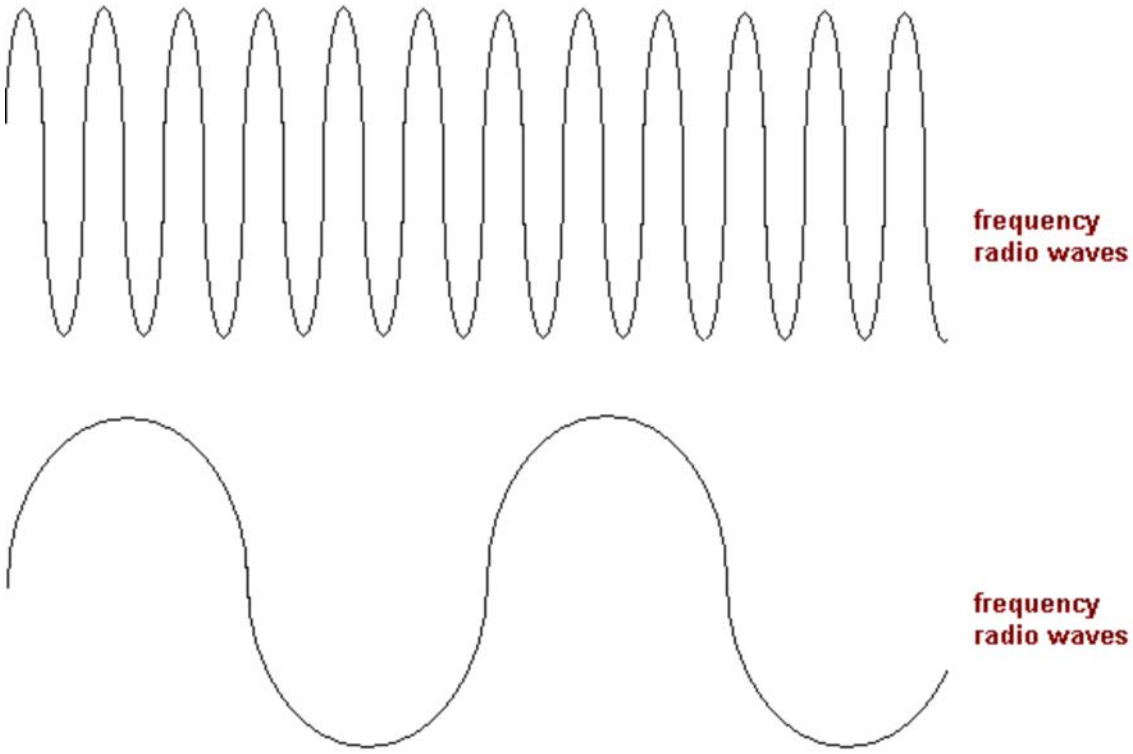



*Note. From "SparkNotes", 2006, Crests, Troughs, and Wavelength. Retrieved October 24, 2008, from http://sparknotes.com/testprep/books/sat2/physics/chapter17section2.rhtml*

Figure A-2 Crest, Troughs and Trough



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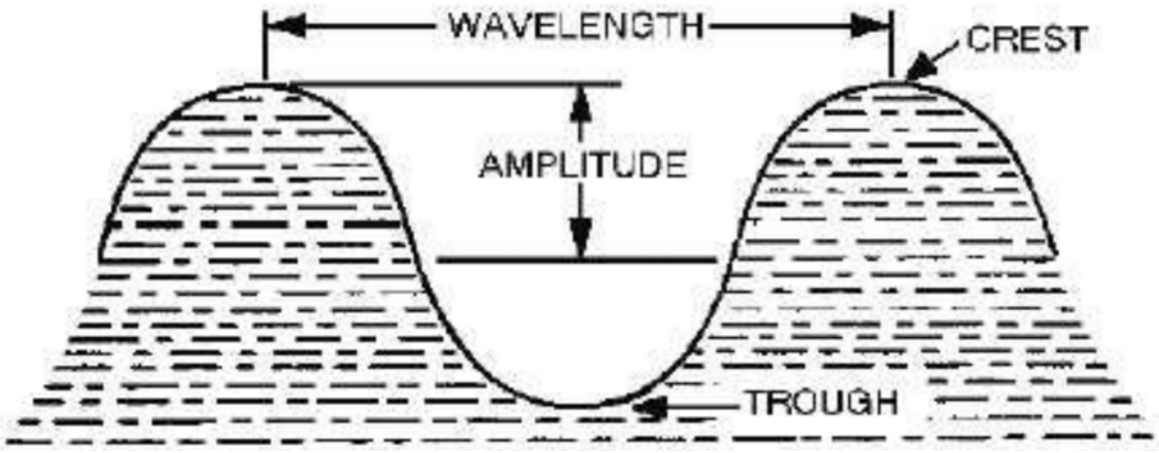



*Note. From "Communications System", What is Frequency? Retrieved October 24, 2008, from http://qrg.northwestern.edu/project/vss/docs/Communications/1-what-is-frequency.html*

Figure A-3 Radio Wave Frequencies

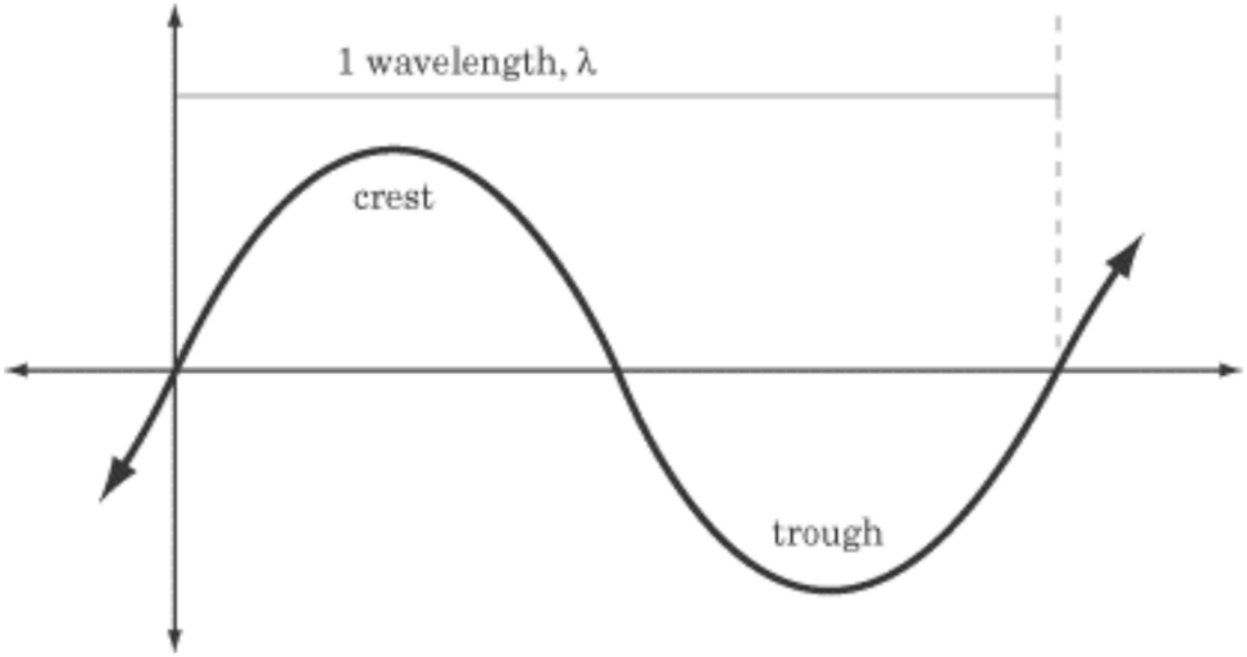


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Figure B-1 Transverse Wavelength

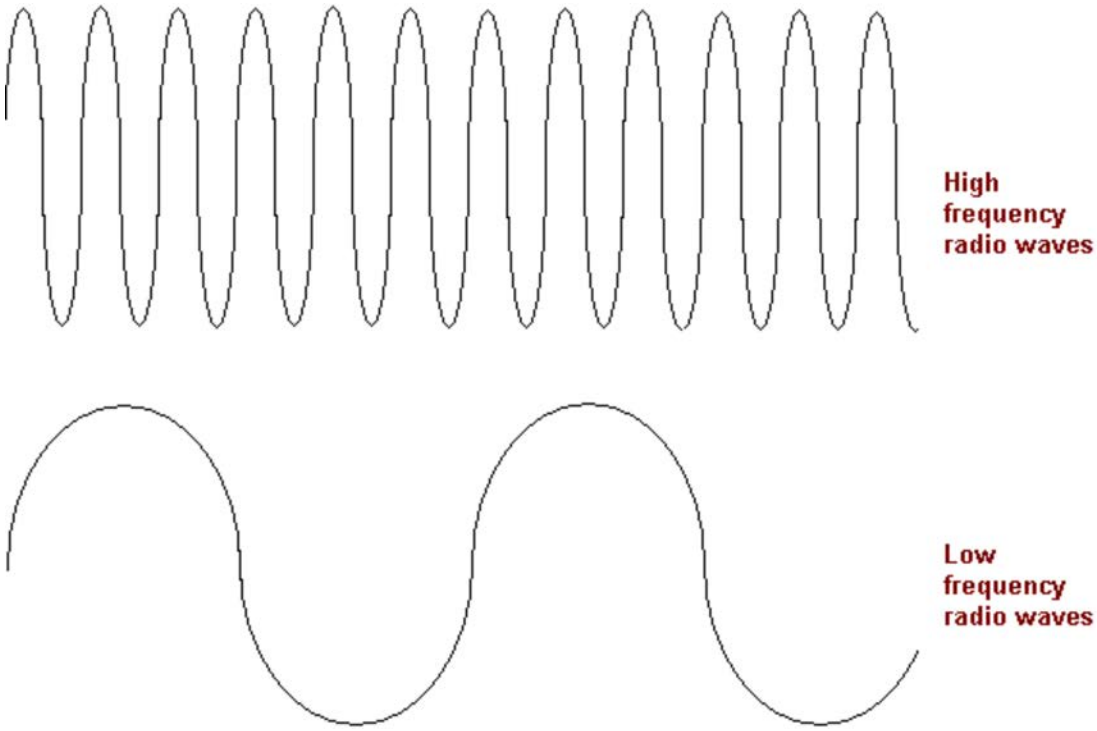



*Note. From "SparkNotes", 2006, Crests, Troughs, and Wavelength. Retrieved October 24, 2008, from http://sparknotes.com/testprep/books/sat2/physics/chapter17section2.rhtml*

Figure B-2 Crest, Troughs and Trough



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Verify against the official publication.

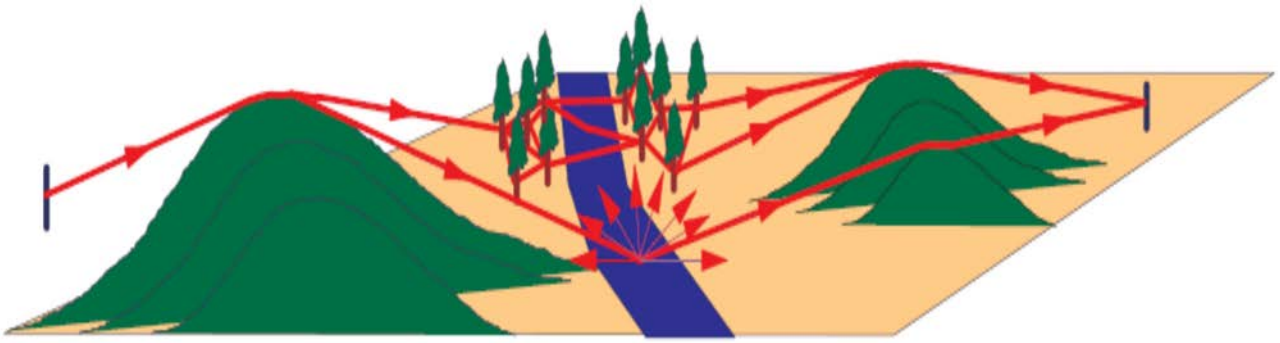



*Note. From "Communications System", What is Frequency? Retrieved October 24, 2008, from http://qrg.northwestern.edu/project/vss/docs/Communications/1-what-is-frequency.html*

Figure B-3 Radio Wave Frequencies

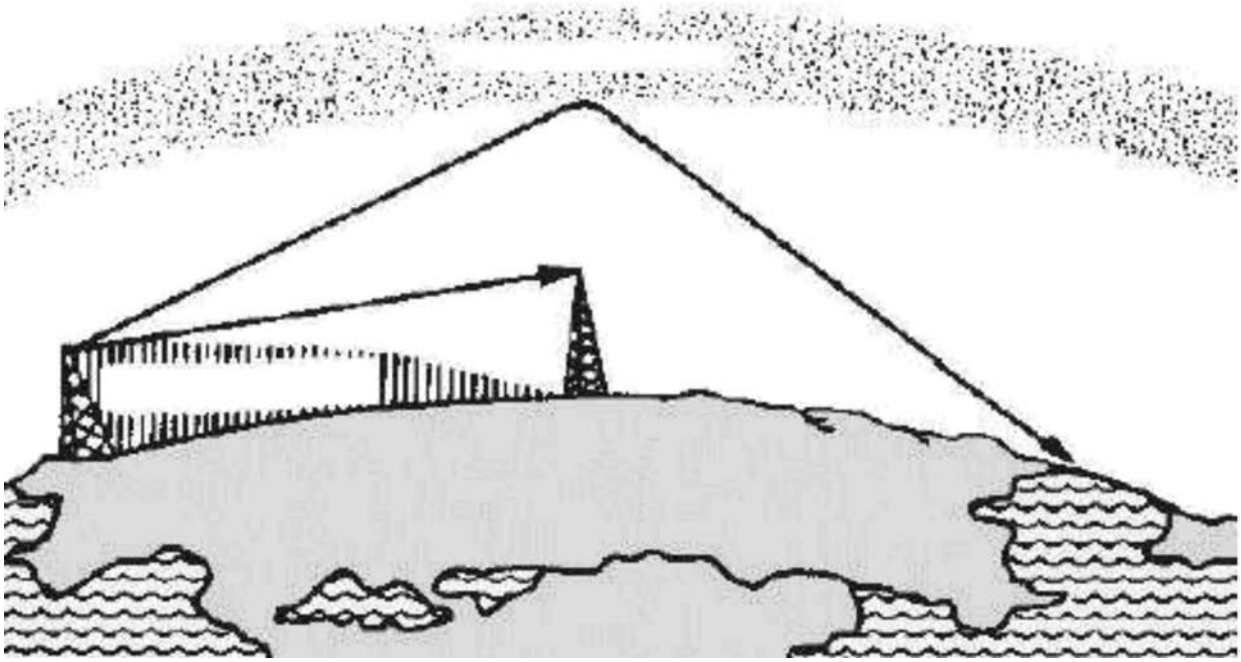


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Verify against the official publication.



*Note. From Radio Wave Diffraction and Scattering Models for Wireless Channel Simulation (p. 5), by M. Casciato, 2001, Michigan: USA. Copyright 2001 by M. Casciato. Retrieved October 31, 2008, from http://www.eecs.umich.edu/RADLAB/html/NEWDISS/Casciato.pdf*

Figure C-1 Ground Wave Transmission



*Note. From "Integrated Publishing", Radio Wave Transmission. Retrieved October 31, 2008, from http://www.tpub.com/content/neets/14182/css/14182_75.htm*

Figure C-2 Sky Wave Transmission

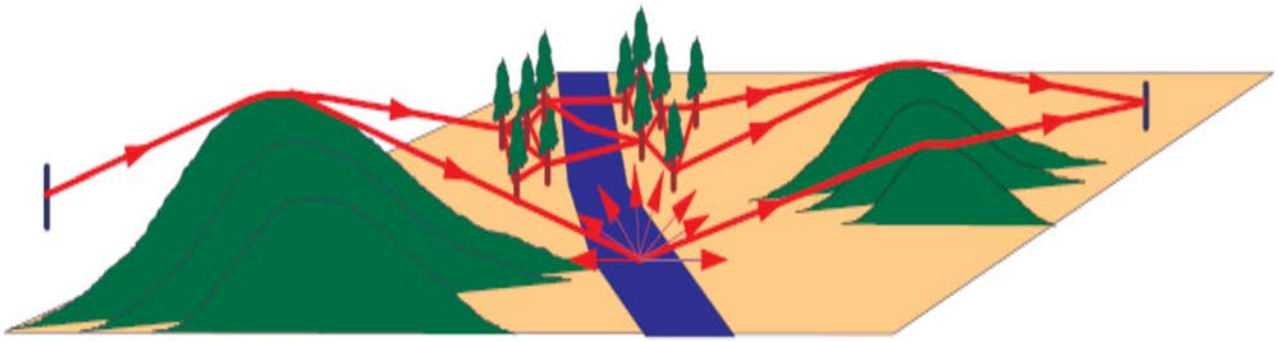


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Verify against the official publication.

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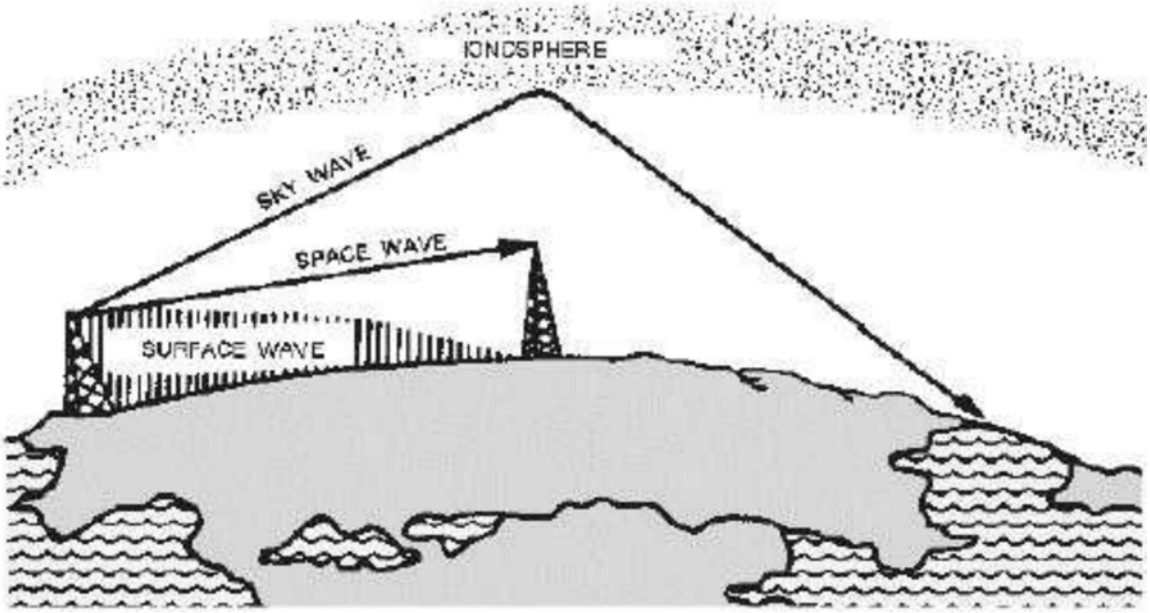


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Figure D-1 Ground Wave Transmission




*Note. From "Integrated Publishing", Radio Wave Transmission. Retrieved October 31, 2008, from http://www.tpub.com/content/neets/14182/css/14182_75.htm*

Figure D-2 Sky Wave Transmission



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