Teacher's Guide

Radio Waves and the Ionosphere

Introduction

When AM radio waves travel from transmitter to a receiver far away, they have to bounce off the underside of the ionosphere to reach a distant receiver. The waves lose some of their energy each time they are reflected. Although this is normally a small amount, less than 5%, it can be several times larger than this during a solar storm. When solar flares erupt, the radiation arrives at the earth 8.5 minutes later and ionizes the D-layer located just below the ionosphere closest to Earth. Radio signals passing through this layer and bouncing off the ionosphere higher up, have some or all of their intensity absorbed. If you were listening to a distant radio station, you would hear its signal suddenly 'fade-out' for 5-10 minutes.

Objective

Students will calculate the ending percentage of radio wave strength at the receiving station.

Procedure

1) Introduce the concept of radio waves in the ionosphere. Be sure to include a discussion about the waves reflecting off of the ionosphere layer and the surface of the Earth, and the impact of a solar storm on these waves. A blank transparency of the Student Page may be helpful for student visualization.
2) Explain that the radio waves normally lose about 5% each time they cross the D-layer just belo the ionosphere. During sola storms, the radio waves can lose as much as 30% with each crossing of the D-layer.
3) Provide students with the examples given, and check for understanding.
4) Allow sufficient time for the students to calculate the percentages, and to determine the remaining signal strength at the receiver's location.
5) Discuss the loss of wave strength and how that may affect communication. Some possible responses may include; mobile phone connections, AM radio station signals, and military communications.

This Lesson can conclude after the discussion, or the following additional procedure may be performed:

6) Group the students into pairs. Have them measure the given angles. Challenge each pair to vary the angle of the bounce to determine if there is an angle that will provide a stronger signal strength. For example, adjust the angle from the transmitter to a smaller degree, creating an isosceles triangle. This will change the number of bounces to a fewer number of triangles, instead of the 8 given in the first example. By decreasing the number of bounces, the signal strength is stronger at the receiver's location. Adjusting the angle to greater than the original will increase the number of bounces required, and in turn decrease the signal strength at the receiver.

Example for one bounce with two passes through the D-layer:

Normal 5% loss:

100% x 0.95 = 95%
95% x 0.95 = 90% (Final)

Solar Storm 30% loss:

100% x 0.70 = 70%
70% x 0.70 = 49% (Final)

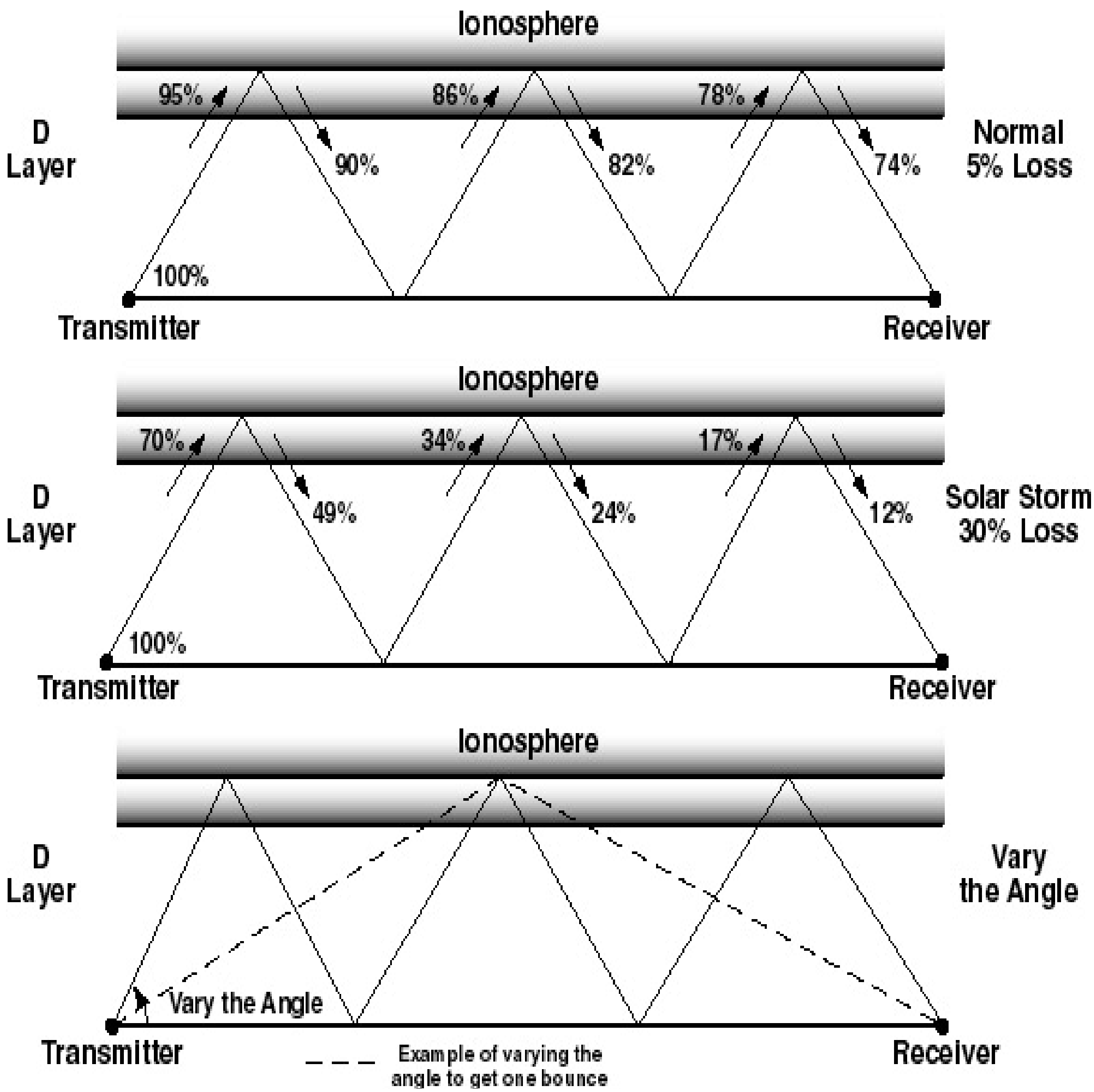
Materials

—Protractor
—Calculator (if available)

Conclusion

Students should learn about real everyday situations that occur with our radio systems. From their discussion, they should address that during a solar flare, the radio waves lose a great amount of strength. Students should realize that solar flares greatly affect daytime long distance communication.

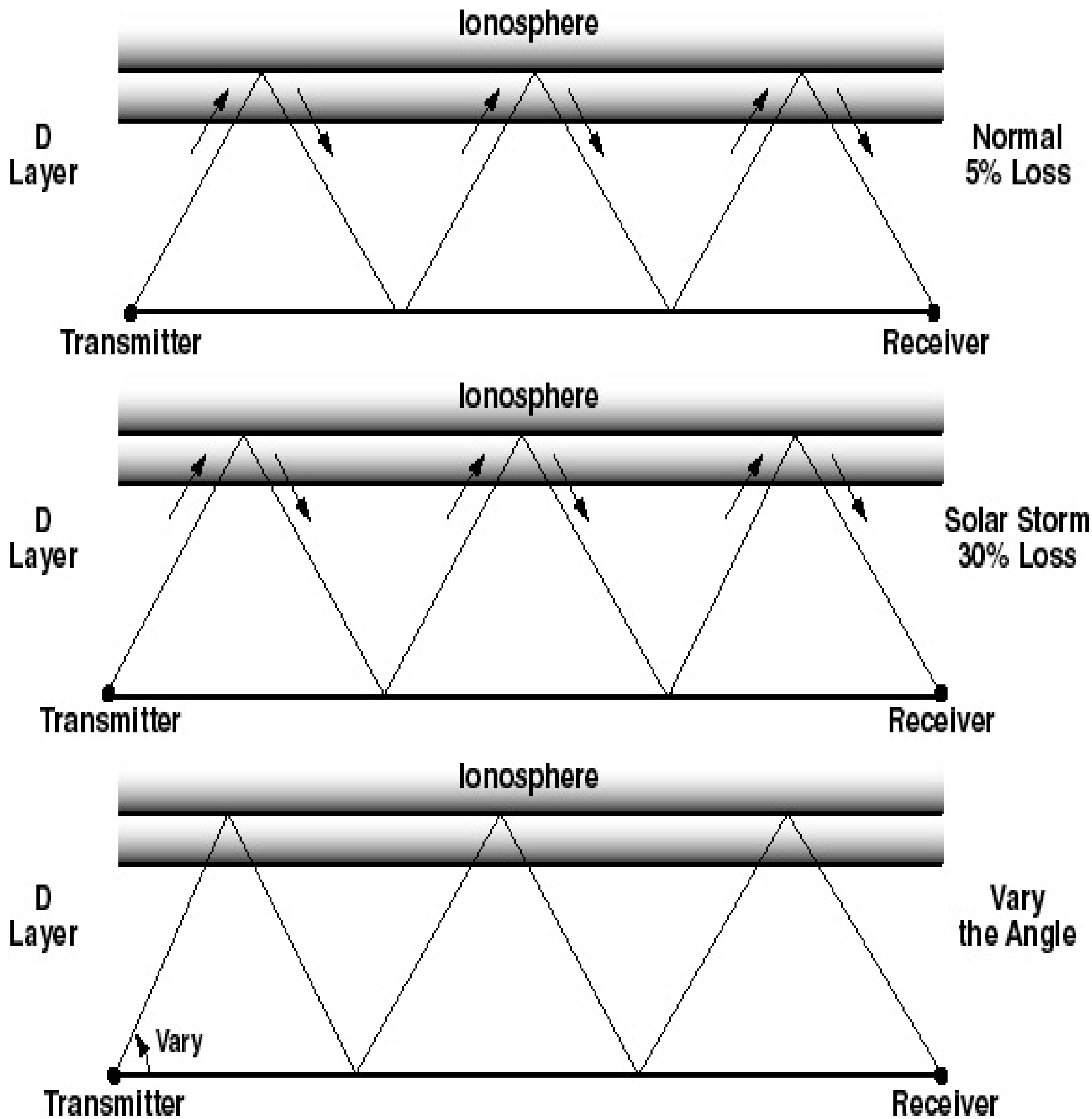
Teacher Answer Key



Radio waves travel from the transmitter to the receiver. The signal bounces from the ground, through a layer called the D-Layer, and is then reflected from the ionosphere back through the D-Layer to the ground. The waves continue to be reflected in this way until they reach the receiver. When the waves pass through the D-Layer they normally lose 5% of their strength. The loss occurs for evey pass through the D-Layer, therefore, there is a 5% loss going up, and a 5% loss going down. When a solar storm occurs, the loss can be about 30%. The engineers have to adjust the angle that the signal is projected to create maximum reception by tilting their ‘satellite dish’. The angle of adjustment must permit the triangles to be isosceles triangles. The wave bounces should be adjusted so that the final bounce is a direct hit to the receiver’s location. If the signal is above or below the receiver’s location, or to either side, there will be no reception.

Name ______________________

Date________________



Calculate the remaining signal strength for each bounce from the transmitter to the receiver. Determine the amount remaining at the receiver's location. Round the answers to the nearest whole number.