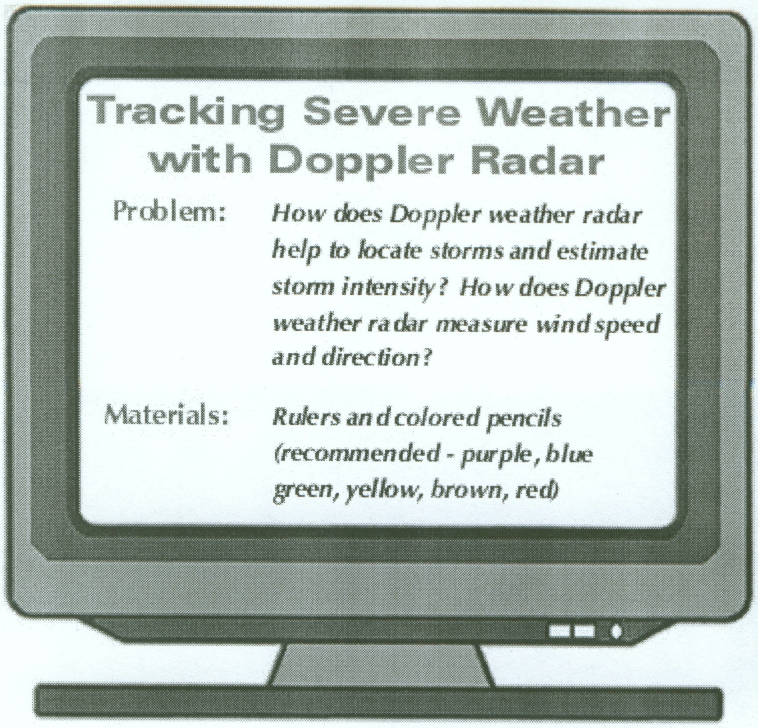

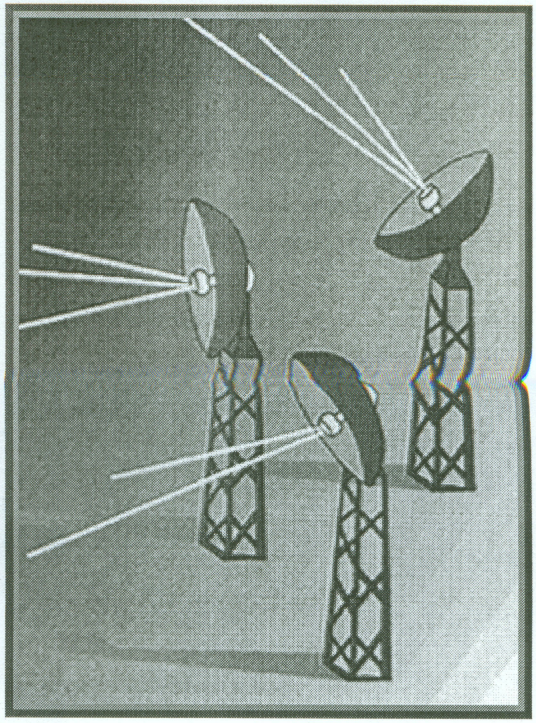

Background Information

Doppler radar is a valuable tool for weather forecasters, research scientists, and air traffic controllers. Doppler weather radar differs from conventional weather radar because it can detect not only where a storm is located, but also how fast air inside the storm is moving. National Weather Service Doppler radars transmit pulses of radio waves at a wavelength of approximately 10 cm (centimeters), about the same as those used to cook food in a microwave oven. Water droplets in the air reflect the pulses. Some of the radio energy returns to the Doppler radar, where it creates a picture of a storm and how it is moving.

More than 150 years ago, a young scientist named Christian Doppler explained this effect. Doppler was studying the motion of waves and predicted that the frequency of a wave (for example, the pitch of a note) would change depending on whether the source of the sound moved toward or away from you. To test the idea, an engineer blew the whistle on a railroad train while an observer standing by the side of the tracks listened to the whistle's pitch as the train approached, passed, and moved away. What Doppler predicted, and the observer confirmed, was that the frequency (pitch) of the source (the whistle) increased or rose as the train approached and decreased or fell as it moved away. More than 50 years later, Albert Einstein demonstrated that this phenomenon, called the Doppler Effect, was also true for electromagnetic waves.

The antenna of a Doppler radar is called a "dish" because of its shape. The radar dish constantly moves (or scans) in a circle at angles between 1 degree and 20 degrees above the horizon. While it scans, the radar sends out radio pulses and listens for the return signal reflected from airborne particles.

The Doppler radar can detect small changes in the frequency of the returned signal as precipitation moves either toward or away from the radar. Droplets moving with the air are a good indicator of wind speed in a storm. When the air moves away from the radar, the frequency of the returned signal is lower than the transmitted signal, just as the pitch of a train whistle appears to fall as the train moves away from you. When the air moves toward the Doppler radar, the frequency of the returned signal is higher. Try to imagine how the frequency and wavelength of the reflected radar signal changes depending on how the storm in Figure 1-1 is moving.

Figure 1-1. Doppler Radar in Three Weather Situations.

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Police traffic radars work in the same way.

The location of a storm or cloud is detected by the strength or intensity of the radar signal reflected from the water in it. The higher the moisture content in a region of a storm or cloud, the greater its intensity, or reflectivity. Therefore, Doppler radar not only shows the location of the storm, but it can also show where in the storm most of the moisture is located. For these reasons, Doppler radar is especially good at detecting severe weather, such as hail storms or tornados. On the radar screen, hail appears as the most dense, rain is less dense, and snow is least dense. Airplanes and swarms of insects also reflect radar waves, but experienced forecasters can easily tell the difference.

The data for this activity were collected from the Mile High Doppler radar site east of the former Stapleton International Airport in Denver, Colorado. The radar image shown in Figure 1-2, the worksheet for this activity, was generated by analyzing the Doppler pitch of a winter storm that occurred on March 9, 1992, at 9:45 pm.

Figure 1-2. Doppler Radar Display of Wind Velocity in Meters/Second, Observed at the Mike High Radar, Denver, Colorado, on March 9, 1992, at 9:45 pm.

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The storm dropped large amounts of snow on Denver and the surrounding area. In the worksheet for this activity, you are looking at the motion of the snowflakes as recorded by the Doppler radar. This view is different from the view of storm intensity broadcast during daily television weather reports, because it can detect storm movement.

Meteorologists, as well as astronomers and other physical scientists, use the color blue or violet to indicate movement toward the radar and the color red to indicate movement away from the radar. The Doppler Radar Worksheet provides the pattern of Doppler velocities that covers a radius of approximately 20 km around the Mile High Doppler radar site.

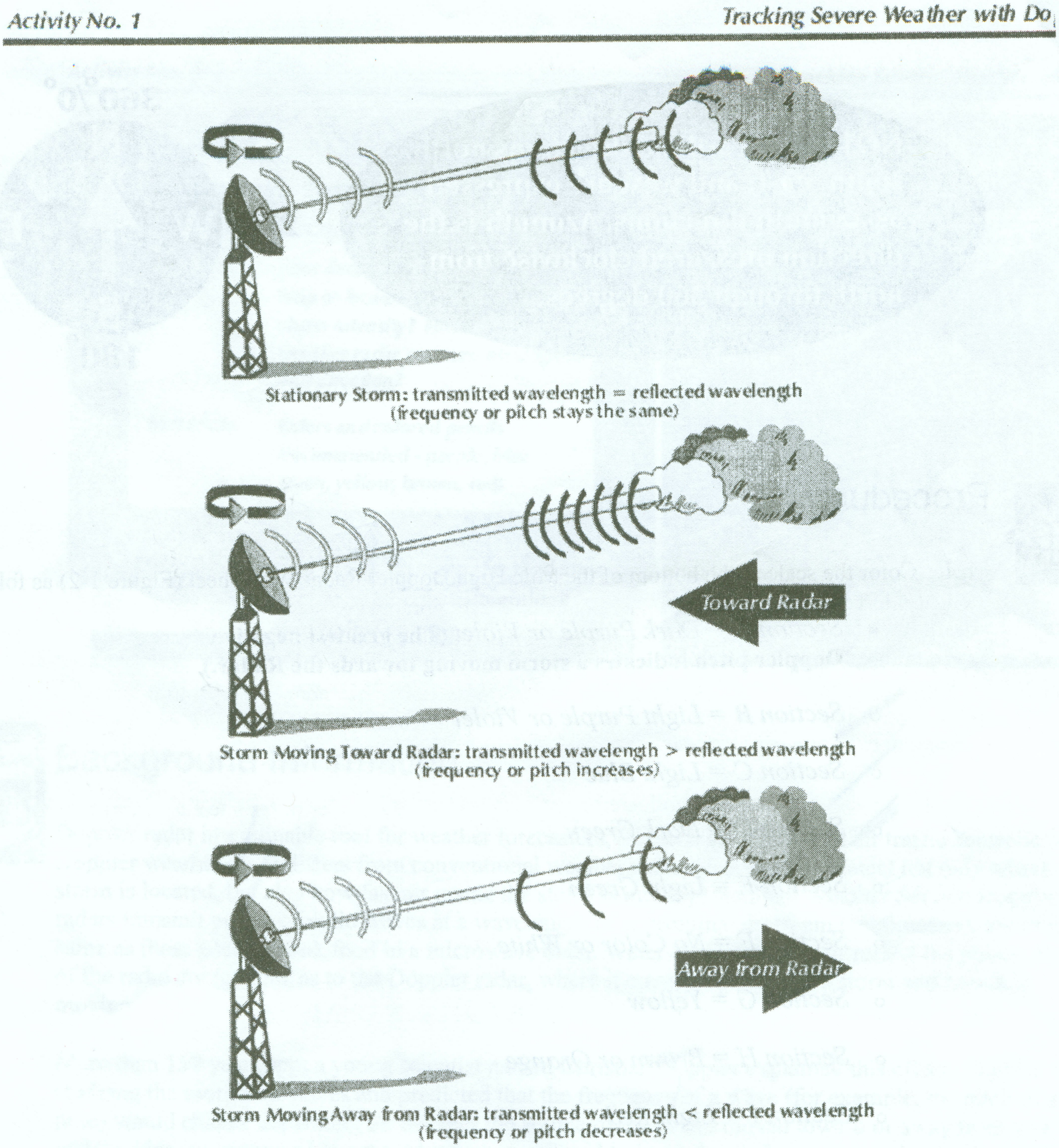
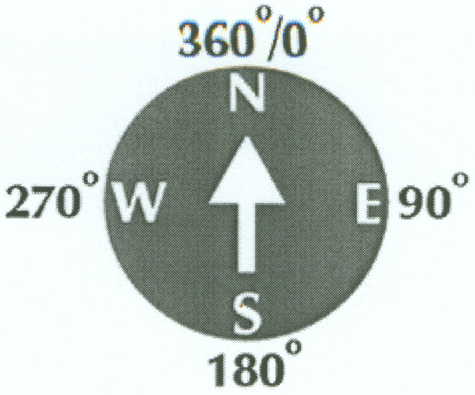


Figure 1.1. Doppler Radar in Three Weather Situations.

NOTE: The cardinal directions north, south, east, and west are expressed as azimuth directions. Azimuth is the direction measured clockwise from north through 360 degrees.

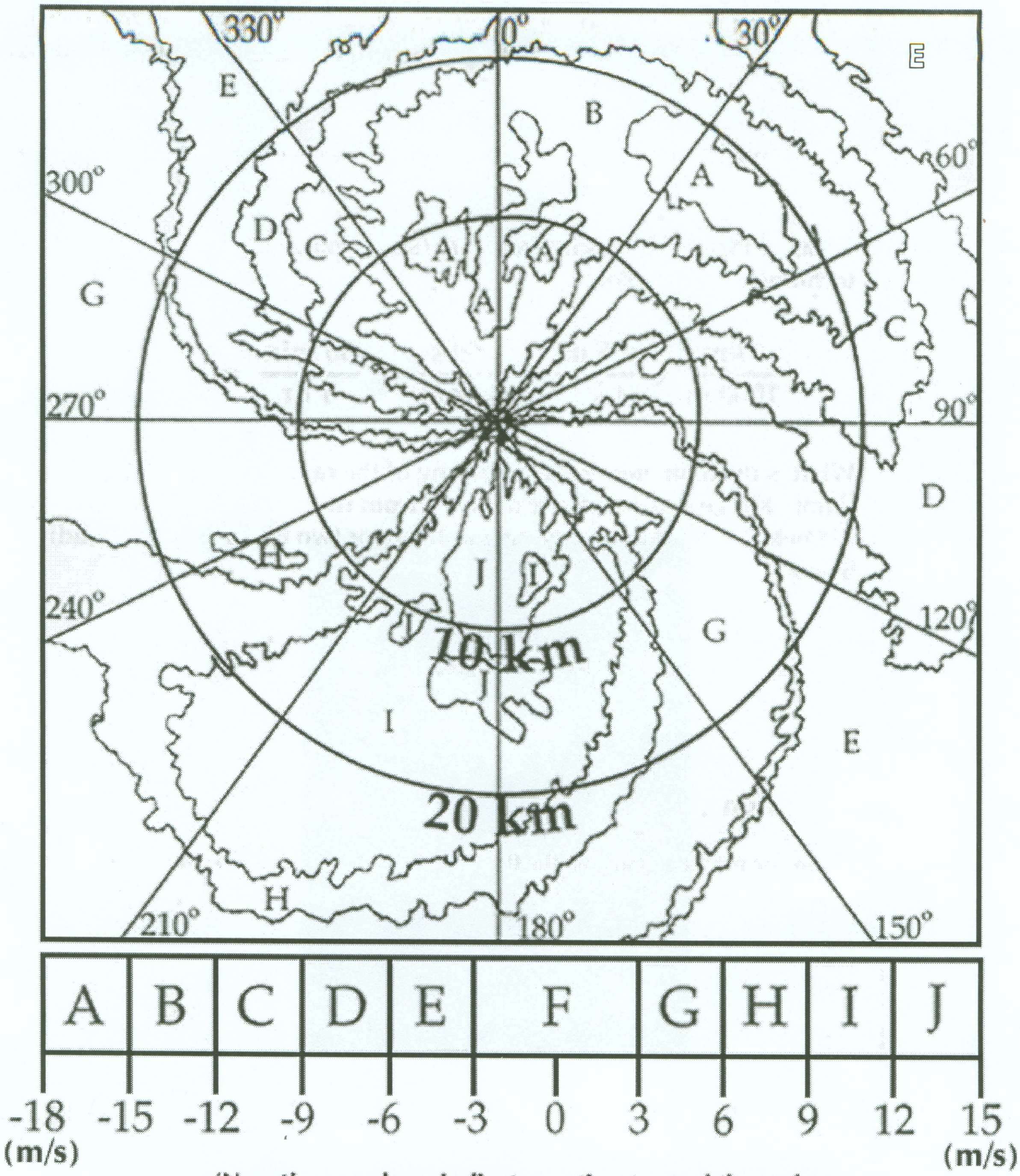


Procedure

1. Color the scale at the bottom of the Mile High Doppler Radar Worksheet (Figure 1-2) as follows:

    - *Section A = Dark Purple or Violet* **(The greatest negative Doppler pitch indicates a storm moving towards the Radar.)**
    - *Section B = Light Purple or Violet*
    - *Section C = Light Blue*
    - *Section D = Dark Green*
    - *Section E = Light Green*
    - *Section F = No Color or White*
    - *Section G = Yellow*
    - *Section H = Brown or Orange*
    - *Section I = Light Red*
    - *Section J = Dark Red* **(The greatest positive Doppler pitch indicates a storm moving away from the Radar.)**

2. Note that there are letters assigned to each area of the radar image indicating the wind speed range in that area. Using these letters and your completed scale as a key, fill in the colors



(Negative numbers indicate motion toward the radar, while positive numbers indicate motion away from the radar.)

Questions

1. If the 0° azimuth on the radar screen is north, what direction is 90°?

   90°?________ 180°?________ 270°?________

2. Place a ruler on the part of the zero velocity line that runs through the radar station. The wind blows perpendicular to this line.
   What direction is the wind coming from? ________________________

3. What two colors represent the fastest air velocities, and what are their speeds in meters per second?

   ____

4. Change the wind velocity from 9 meters per second (m/s) to miles per hour (mph). Use the unit analysis technique set up below.

$$\_\_\_ \frac{\text{m}}{\text{s}} \times \frac{\text{1 km}}{\text{1000 m}} \times \frac{\text{0.6 mi}}{\text{1 km}} \times \frac{\text{60 sec}}{\text{1 min}} \times \frac{\text{60 min}}{\text{1 hr}} = \_\_\_ \frac{\text{mi}}{\text{hr}}$$

5. What is the diameter of the outer ring of the radar screen in miles?

   ____

   (Hint: Range rings measure distance ***from the radar****. Therefore, the diameter of the outer range ring is 40 km or two times the 20 km radius.)*

   Show your work here.

   Does the storm cover this entire area?