DISCOVERY OF MAGNETIC DIP

TOPIC:

Earth's Magnetic Field

SCIENTIST:

Robert Norman c.1550–c.1600

INTRODUCTION:

As a navigator with many years' experience at sea, Robert Norman knew all about the shortcomings of the navigational instruments and techniques used by seafarers. Norman was especially interested in the magnetic compass, and he researched into the variation of *magnetic* north from *true* north, showing that it was not regular as had been assumed before. At the same time he noticed that in addition to turning toward the north, the magnetized compass needle also dipped from the horizontal, even when carefully balanced on its pivot. At first he thought there was something wrong with his construction technique, which he tried to correct. As he wrote in his book *The Newe Attractive*, published in 1581, he felt "...constrained to put some small piece of ware in the south part thereof, to counterpoise this declining, and to make it equal again." Whatever he tried, however—whether it was adding weight to one side of the needle or making one side of the needle shorter—the declination or dip was still there. Frustrated by his fruitless attempts, Norman decided to investigate the effect further. He pivoted the compass needle on a horizontal axis so he could measure the angle of dip, an experiment you will now repeat. He suspected, correctly, that the angle of dip or declination would depend on the latitude at which it was measured. To exploit this idea he developed the dip circle—a magnetic needle mounted horizontally against a scale—to be used by navigators at sea. We now know that the angle of dip is the angle between the earth's magnetic field and the horizontal.

TIME NEEDED:

45 minutes

MATERIALS:

thin steel knitting needle or thin steel rod
strong bar magnet
cotton thread
scissors
protractor
spirit level
Fun tak®
waterproof marker
directional compass
metric ruler

Original Materials:

Norman used a fine needle and a fixed horizontal pivot.

Safety Precautions

Please read and copy the safety precautions at the beginning of this book.

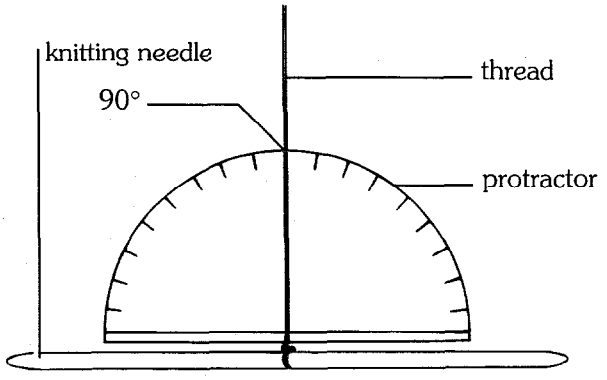
PROCEDURE:

1. Find a flat vertical surface (*e.g.*, side of a bookcase, wall, etc.) that runs from north to south (*i.e.*, it faces east or west). Check the direction with a directional compass.
2. Use a small piece of Fun tak® to stick the protractor to the surface, described in step 1, at eye level. Use the spirit level to check that the protractor is horizontal.
3. Use the ruler to find the middle of the knitting needle. Mark it on the needle with the marker.

4. Cut a piece of cotton thread 30 cm long. Tie one end of the cotton thread around the center of the knitting needle.

5. Hold the knitting needle by the thread next to, but not touching, the protractor. Check that the needle is perfectly balanced and horizontal by holding the thread parallel with the 90° mark on the protractor, checking that the needle is parallel to the horizontal line on the bottom of the protractor (see figure 1).

Figure 1

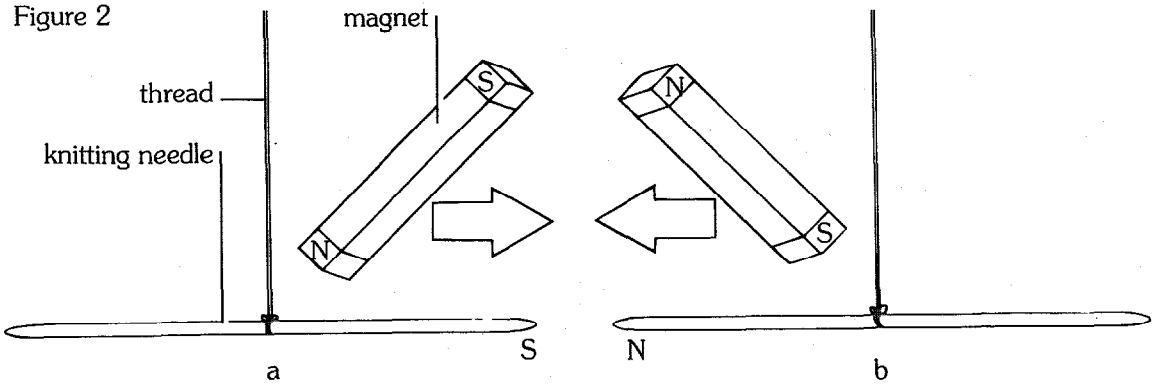


6. If the needle is not balanced, move the thread slightly until it is. Then make four or five more turns of thread around the needle and tie tightly.

7. Magnetize the knitting needle as follows. Take the bar magnet and carefully stroke the knitting needle from its center to one end with the north pole of the magnet 20 times (see figure 2a). Mark that end of the needle "S" (for south pole).

8. Repeat step 7 but this time use the south pole of the magnet and stroke the knitting needle from its center to the opposite end 20 times (see figure 26). Mark that end of the needle "N" (for north pole).

Figure 2



9. Hold the knitting needle next to, but not touching, the protractor. Hold the thread parallel to the 90° mark.

10. Look at the position of the needle. Make a note of whether the angle of the needle has changed. If the angle has changed, make a note of the new angle and which end (N or S) has dipped.

ANALYSIS:

1. Why was the protractor attached to a surface running parallel to the north–south axis?

2. What did you observe when the magnetized needle was held against the protractor? What was the angle between the knitting needle and the horizontal?

3. Do some research. Explain your observations. Would it matter whether you carried out the experiment at the equator, in New York, or at the north pole? How?

OUR FINDINGS:

Click on above link to see what we found.

SPECIAL SAFETY NOTE TO EXPERIMENTERS

Each experiment includes any special safety precautions that are relevant to that particular project. These do not include all of the basic safety precautions that are necessary whenever you are working on a scientific experiment. For this reason, it is absolutely necessary that you read, copy, and remain mindful of the General Safety Precautions that follow this note.

Experimental science can be dangerous, and good laboratory procedure always includes carefully following basic safety rules. Things can happen very quickly while you are performing an experiment. Things can spill, break, even catch fire. There will be no time after the fact to protect yourself. Always prepare for unexpected dangers by following basic safety guidelines the *entire* time you are performing the experiment, whether or not something seems dangerous to you at a given moment.

We have been quite sparing in prescribing safety precautions for the individual experiments. We made this choice for one reason: We want you to take very seriously every safety precaution that is printed in this book. If you see it written here, you can be sure that it is here because it is absolutely critical to your safety.

One further note: The book assumes that you will read the safety precautions that follow, as well as those in the box within each experiment you are preparing to perform, and that you will *remember* them. Except in rare instances, these precautions will not be repeated in the procedure itself. It is up to you to use your good judgment and pay attention when performing potentially dangerous parts of the procedure. Just because the book does not say BE CAREFUL WITH HOT LIQUIDS or DON'T CUT YOURSELF WITH THE KNIFE does not mean that you should be careless when simmering water or stripping an electrical wire. It does mean that when you see a special note to be careful, it is extremely important that you pay attention to it.

If you ever have a question about whether a procedure or material is dangerous, wait to perform it until you find out for sure that it is safe.

GENERAL SAFETY PRECAUTIONS

Accidents caused by carelessness, haste, insufficient knowledge, or taking unnecessary risks can be avoided by practicing safety procedures and being alert while conducting experiments. Be sure to check the experiments in this book for additional safety regulations and adult supervision requirements. If you will be working in a lab, do not work alone.

PREPARING:
—Clear all surfaces before beginning experiments
—Read the instructions before you start
—Know the hazards of the experiments and anticipate dangers

PROTECTING YOURSELF:
—Follow the directions step-by-step; do only one experiment at a time
—Locate exits, fire blanket and extinguisher, master gas and electricity shut-offs, eye wash, and first-aid kit
—Make sure there is adequate ventilation
—Do not horseplay
—Wear an apron and goggles
—Do not wear contact lenses, open shoes, loose clothing, or loose hair
—Keep floor and work space neat, clean, and dry
—Clean up spills immediately
—Never eat, drink, or smoke in laboratory or work space
—Do not eat or drink any substances tested unless expressly permitted to do so by a knowledgeable adult

USING EQUIPMENT WITH CARE:
—Set up apparatus far from the edge of the desk
—Use knives and other sharp or pointed instruments with caution
—Pull plugs, not cords, when removing electrical plugs
—Don't use your mouth to pipette; use a suction bulb
—Clean glassware before and after use
—Check glassware for scratches, cracks, and sharp edges
—Clean up broken glassware immediately
—Do not use reflected sunlight to illuminate your microscope
—Do not touch metal conductors
—Use only low voltage and current materials such as lantern batteries
—Be careful when using stepstools, chairs, and ladders

USING CHEMICALS:
—Never taste or inhale chemicals
—Label all bottles and apparatus containing chemicals
—Read labels carefully
—Avoid chemical contact with skin and eyes (wear goggles, apron, and gloves)
—Do not touch chemical solutions
—Wash hands before and after using solutions
—Wipe up spills thoroughly

HEATING SUBSTANCES:
—Use goggles, apron, and gloves when boiling water
—Keep your face away from test tubes and beakers
—Never leave apparatus unattended
—Use safety tongs and heat-resistant mittens
—Turn off hot plates, bunsen burners, and gas when you are done
—Keep flammable substances away from heat
—Have fire extinguisher on hand

FINISHING UP:
—Thoroughly clean your work area and glassware
—Be careful not to return chemicals or contaminated reagents to the wrong containers
—Don't dispose of materials in the sink unless instructed to do so
—Wash your hands
—Clean up all residue and put in proper containers for disposal
—Dispose of all chemicals according to all local, state, and federal laws

BE SAFETY CONSCIOUS AT ALL TIMES