Teachers notes and answers

Science curriculum links:	forces, Earth and space, working scientifically
Maths curriculum links:	geometry – shape, position and direction statistics – line graphs number – fractions, decimals and percentages
Suggested target audience:	upper KS2

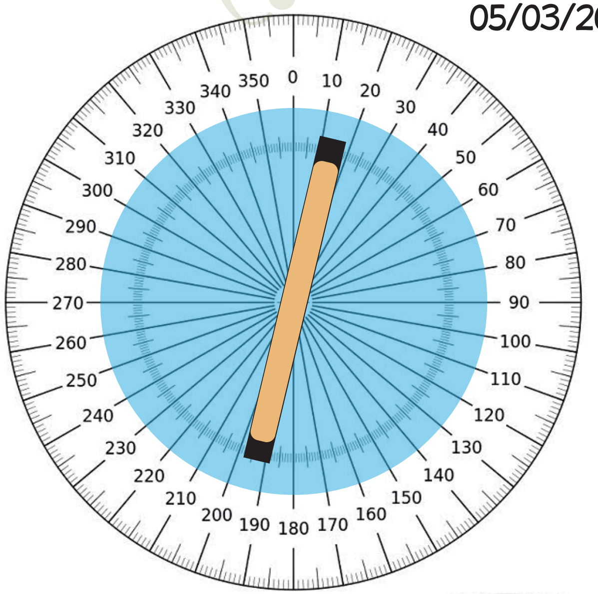
Problems to solve

These problems link children's prior learning about magnetic forces from Year 3 with their learning about Earth and space. It would work well as a transition activity between Earth and space and forces in Year 5, helping children to connect their learning in different topics. The first problem is all about taking measurements from a homemade magnetometer to try and identify solar storms. There is a supplementary Phizzi practical resource, *How to make a magnetometer,* so that children can carry out this enquiry themselves, providing opportunities to make observations over time and practise measuring angles.

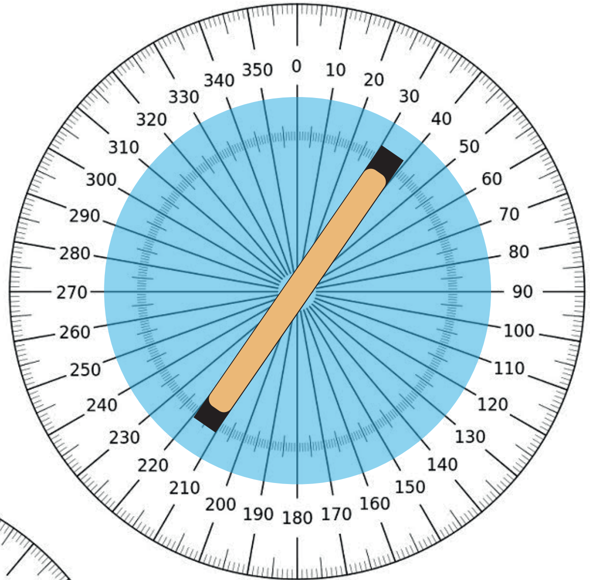
1) The class worked in teams to build their own magnetometer, a measuring instrument which can measure slight changes in Earth's magnetic field. They decide to see if they can use their magnetometers to predict when solar storms have happened. They set up their magnetometers on a bench, placed on top of a print out of a 360° protractor. The children lined up the north pole of the magnet with 0° as its starting point once the hanging magnet had settled. Each day, at the same time, they recorded the position of the north pole on the protractor.

Should you repeat this investigation, you will find that it is exceptionally difficult to make accurate measurements with the magnetometer. Slight changes in the position of the observer will lead to completely different angles being measured. This is a good thing – it provides a great opportunity to talk about accuracy and reliability of data. Children can develop their evaluation skills and try to devise better ways to measure the movement of the magnet. Other problems arise when the magnets are unable to swing freely so don't move at all or the magnets move randomly when the bench the magnetometers are on is knocked.

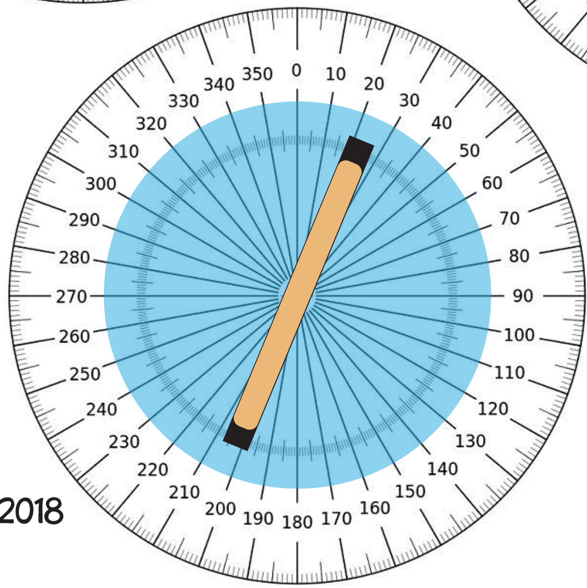
(a) Leah and Cameron read the angle position of the north pole every day over a month and record their data in a table. Use these images to complete their measurements and add this data to the results table.



05/03/2018



19/03/2018



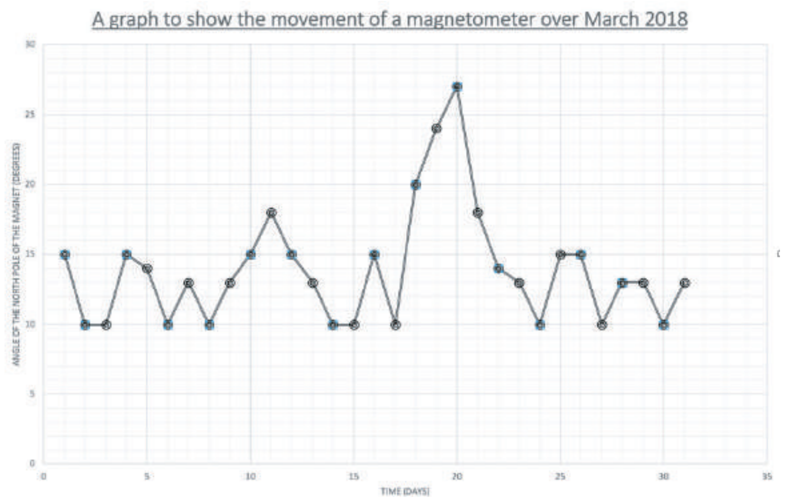
20/03/2018

Day	Date	Angle of the north pole (degrees)
1	01/03/2018	15
2	02/03/2018	10
3	03/03/2018	10
4	04/03/2018	15
5	05/03/2018	14
6	06/03/2018	10
7	07/03/2018	13
8	08/03/2018	10
9	09/03/2018	13
10	10/03/2018	15
11	11/03/2018	18
12	12/03/2018	15
13	13/03/2018	13
14	14/03/2018	10
15	15/03/2018	10
16	16/03/2018	15
17	17/03/2018	10
18	18/03/2018	20
19	19/03/2018	24
20	20/03/2018	27
21	21/03/2018	18
22	22/03/2018	14
23	23/03/2018	13
24	24/03/2018	10
25	25/03/2018	15
26	26/03/2018	15
27	27/03/2018	10
28	28/03/2018	13
29	29/03/2018	13
30	30/03/2018	10
31	31/03/2018	13

Children can discuss how to make an accurate measurement from the pictures. Lining up a ruler with the centre of the magnet makes it easy to read the angle measurement. When sharing the measurements, you could question children on the changes in angle from day to day, practising simple number calculations. In this case, the magnet always swung in a clockwise direction, you could discuss how you would record the movement if it swung in the opposite direction. Perhaps you could record clockwise angles as positive values and anticlockwise angles as negative values? If the children do this investigation themselves, they could plan and draw their own results tables and look at working in groups to record multiple measurements where each member of the group measures the angle. This would also allow for the introduction of mean average calculations.

(b) You now have a complete set of data for observing the Earth's magnetic field over the month of March. Draw a line graph of Leah and Cameron's data.

This problem could be differentiated for different children. Some could be given axes already labelled with an appropriate scale, as shown. The aim in upper KS2 is for children to be confident in planning their own axes for a set of experimental data so this is a good opportunity for children to plan and draw their own axes.

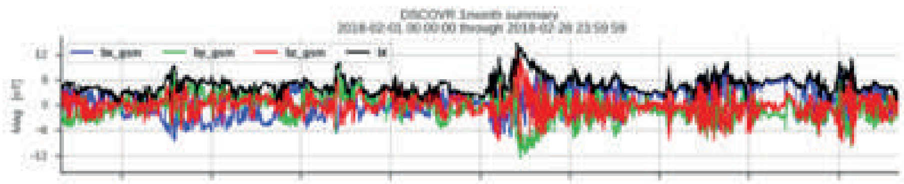


(c) From your line graph, do you think there was a solar storm in March? Explain your answer.

The children look carefully at the line graph to see if they can identify any features (significant peaks) that might suggest that a solar storm has happened.

The graph shows that the magnet mostly swung between 10° and 15° over the month of March. There is a tiny peak on day 11, but this is quite small and could be due to a mistake in measuring or knocking the table. There is a big peak between day 17 and day 21. I think there could have been a solar storm then.

If you make your own magnetometer to carry out this investigation in the classroom and think that you spot a solar storm in your data, you can check accurate space weather data from National Oceanic and Atmospheric Administration (NOAA). Visit www.ngdc.noaa.gov/dscovr/portal/ and enter the dates for your observations; see if there are any similarities between their data and yours. For example, The Deep Space Climate Observatory (DSCOVR) is a satellite that constantly monitors the solar wind, it has a magnetometer on board and here is the trace for March 2018. You can see there is a peak on the magnetometer reading at a similar point in the month.



(d) Brinda and Ali also collected data over the month of March. This is the line graph of their results. Answer the following questions to compare their results with Leah and Cameron's data.

(i) On what day was Brinda and Ali's north pole positioned at the greatest angle from its start position? What angle did they measure that day?

They measured the largest angle on day 19, the angle was 30°.

ii **On what day was Leah and Cameron's north pole positioned at the greatest angle from its start position? What angle did they measure that day?**

Leah and Cameron measured the largest angle on day 20, the angle was 27°

iii **Did the two groups measure their greatest angle on the same day? How did their measurements compare?**

The two groups didn't measure their greatest angle on the same day. They did measure them on days next to each other (day 19 and 20) and Cameron and Leah have a peak in their data that stretches over day 19 and 20. They both have measured a change in the magnetic field at the same point of the month. Brinda and Ali's data seems more spread out than Leah and Cameron's.

(e) **Could you use the magnetometer to make accurate measurements? How could you improve the design of the magnetometer to make it easier to measure angles accurately?**

From the diagrams in part (a) it was easy to use a ruler to measure what angle the magnet was at. On the photo with shadows it looks much more difficult to measure what angle the magnet is at.

Children will come up with a range of ideas to improve their design, possible suggestions could be:

- **Stick a pointer to the magnet so it is easier to see what angle it is pointing at.**
- **Have a camera fixed above the magnetometer, taking a zoomed in video that you can pause to make measurements.**
- **Make the magnetometer shorter so the magnet is closer to the protractor.**
- **Attach a laser pen to the magnet so that it swings with it. If the laser pen is pointed at the wall you could mark the position of the light dot on the wall.**
- **Put a magnetometer on a satellite in space so no one can knock it.**

2. Solar storms often occur after we observe a solar flare, a giant explosion on the surface of the Sun that sends particles and energy off into space. The table below shows how many solar flares there were each month in 2018.

Month	Number of large solar flares recorded
January	2
February	25
March	5
April	1
May	10
June	5
July	1
August	0
September	0
October	1
November	0
December	0

(a) What was the total number of large solar flares recorded in 2018?

There were 50 large solar flares in 2018.

(b) In which month were there the most large solar flares?

The most solar flares happened in February.

(c) In how many months were there no solar flares?

There were no large solar flares in four months (August, September, November and December).

(d) What fraction of 2018's large solar flares were recorded in May?

$\frac{10}{50}$ of 2018's large solar flares happened in May. That is $\frac{1}{5}$.

(e) What percentage of 2018's large solar flares were recorded in February?

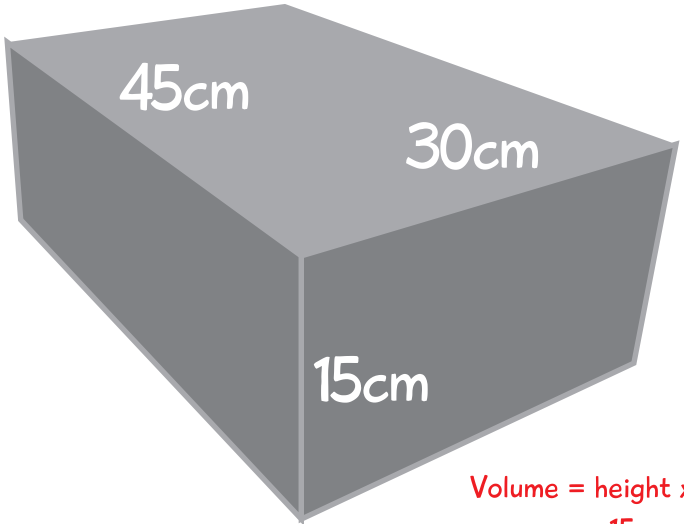
50% of 2018's large solar flares were recorded in February.

(f) In which month would you have expected their magnetometer to move the most?

I would have expected the magnetometer to move the most in February.

3. Scientists sometimes place magnetometers on space probes and satellites so that they can measure magnetic fields in different places in the solar system. When designing and building satellites, scientists need to think carefully about size, mass and cost.

(a) A magnetometer instrument designed to go on a satellite is a cuboid shape with the dimensions shown in the diagram. Calculate the volume of this instrument?



Volume = height x width x depth
= 15cm x 30cm x 45cm
= $20{,}250cm^3$

(b) The total volume of the satellite is $60{,}750cm^3$. The satellite also needs to carry a camera to collect images and send them back to Earth. What is the maximum volume that the camera can have?

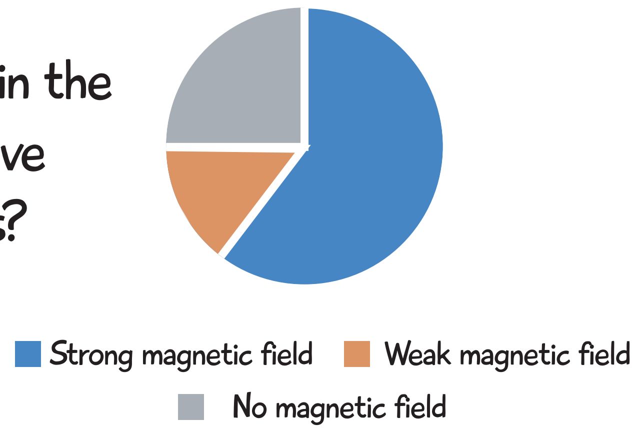
Maximum volume of camera
= volume of satellite - volume of magnetometer
= $60{,}750cm^3 - 20{,}250cm^3$
= $40{,}500cm^3$

(c) What fraction of the space on the satellite is taken up by the magnetometer?

$\frac{1}{3}$ of the space in the satellite is taken up with the magnetometer.

4. The Earth's core is made of liquid iron and causes planet Earth to be magnetic, we say it has a magnetic field around it. Not all planets have magnetic fields; the pie chart compares the planets in our solar system that have and haven't got magnetic fields.

How many planets in the solar system have magnetic fields?



(a) What fraction of planets in the solar system do not have a magnetic field?

$\frac{1}{4}$ of the planets have no magnetic field.

(b) What fraction of planets in the solar system have a weak magnetic field?

$\frac{1}{8}$ of planets in the solar system have a weak magnetic field.

(c) How many planets in the solar system have a strong magnetic field?

$\frac{5}{8}$ of planets in the solar system have a strong magnetic field.
As there are 8 planets in the solar system, $\frac{1}{8}$ of the pie chart represents 1 planet. This means that 5 planets have strong magnetic fields.

Children could carry out a research enquiry to find out which planets are magnetic and which are not, perhaps finding out what their cores are made from.

For information: planets have magnetic fields because of their moving, liquid metal cores. The liquid metal moves because of convection currents and the planet's rotation. Venus and Mars have no magnetic field, although Mars did have one in the past. Mercury has a weak magnetic field because it rotates so slowly. Earth and the gas giants (Jupiter, Saturn, Uranus and Neptune) all have strong magnetic fields.

Phizzi problem solving

Age 9-11 years

Magnetometer

Problems to solve

Mrs Flaherty's Year 5 class has been learning about the Earth and space. They were lucky to have a solar physicist come to talk to them about the Sun and solar storms. They learnt that solar storms can cause slight changes in Earth's magnetic field.

1

The class worked in teams to build their own magnetometer, a measuring instrument that can measure slight changes in Earth's magnetic field. They decide to see if they can use their magnetometers to predict when solar storms have happened. They set up their magnetometers on a bench, sat on top of a printout of a 360° protractor. Once the hanging magnet had settled in one place, the children lined up the north pole of the magnet with 0° on the paper protractor. Each day, at the same time, they recorded the position that the north pole of the magnet pointed to.

(a) Leah and Cameron read the angle position of the north pole every day over a month and record their data in a table. Use the images on the next page to complete their measurements and add this data to the results table.

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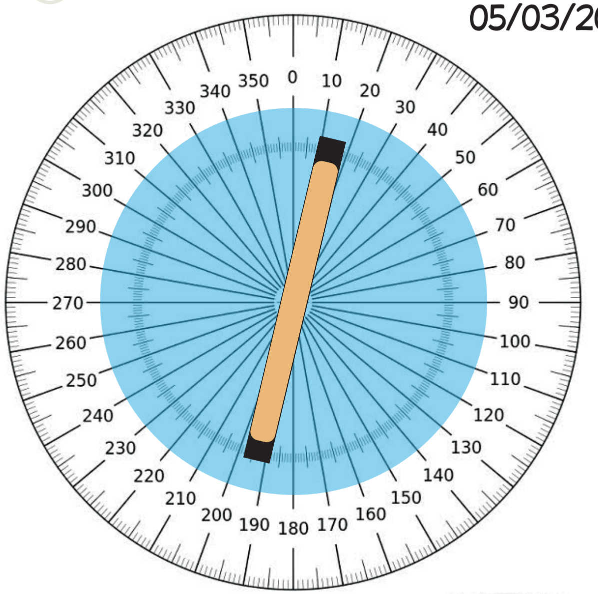

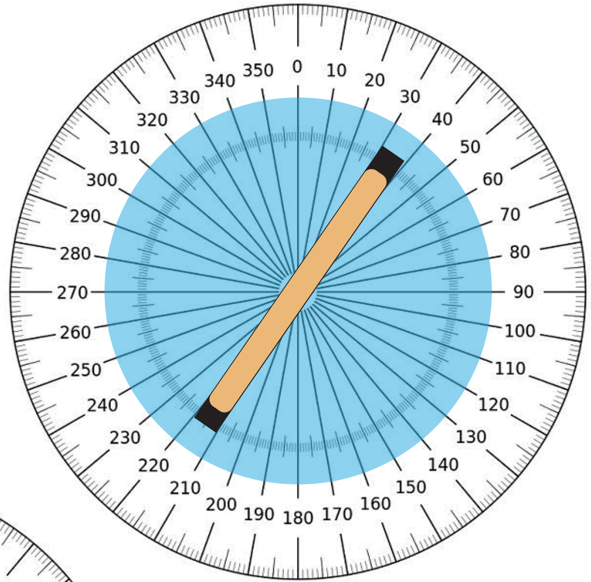

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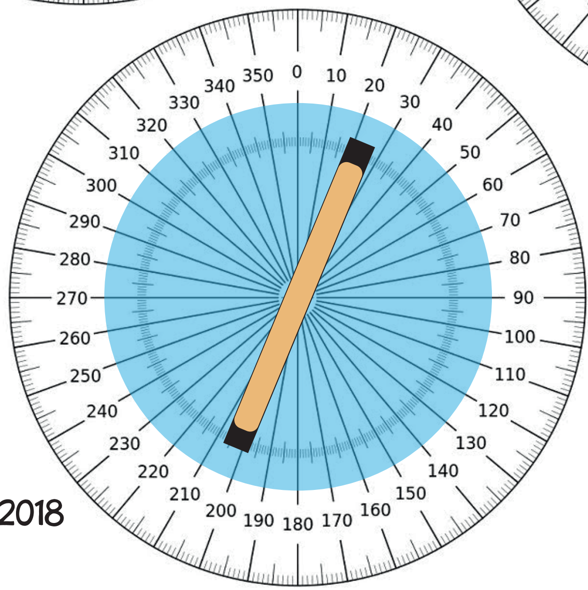

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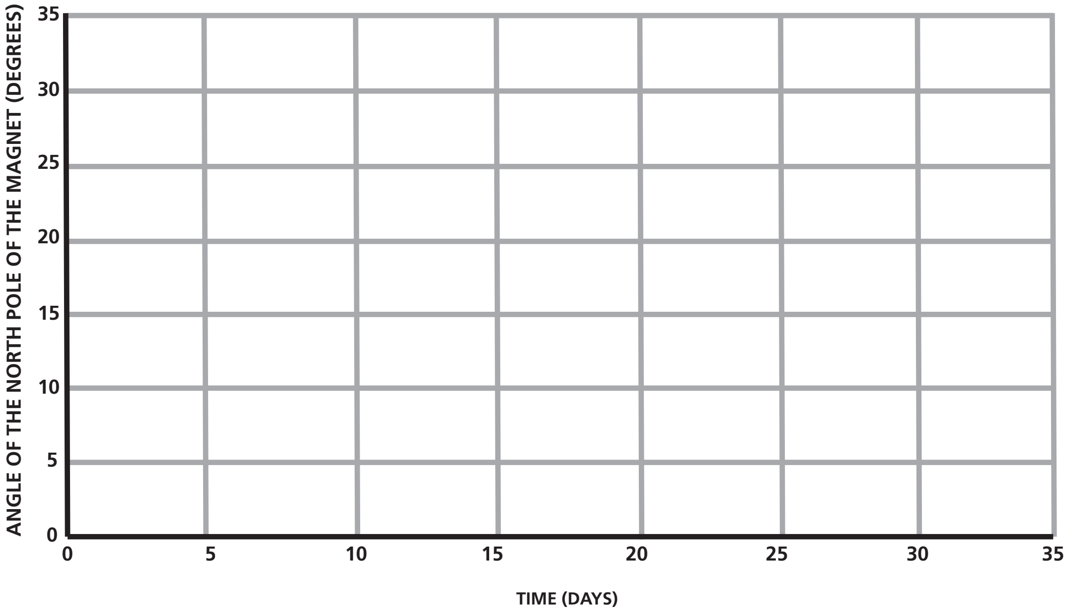
A GRAPH TO SHOW THE MOVEMENT OF A MAGNETOMETER OVER MARCH 2018



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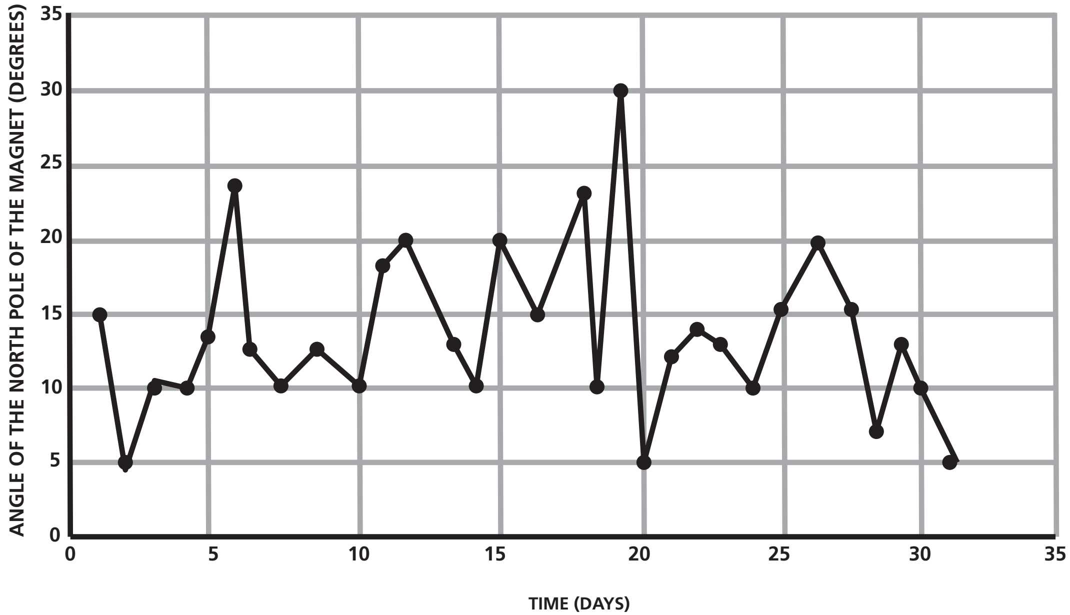

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(b) In which month were there the most large solar flares?

(c) In how many months were there no large solar flares?

(d) What fraction of 2018's large solar flares were recorded in May?

(e) What percentage of 2018's large solar flares were recorded in February?

(f) In which month would you have expected Leah and Cameon's solar flare data magnetometer to move the most?

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3

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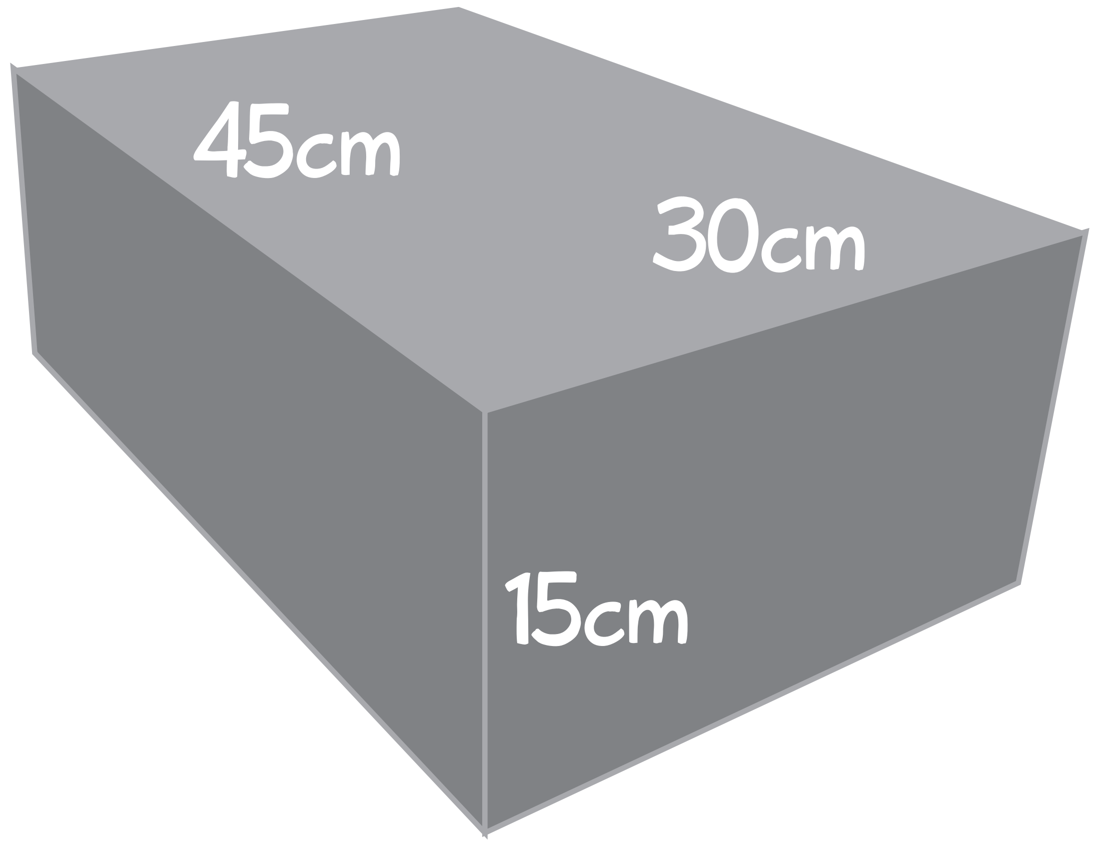

4

The Earth's core is made of liquid iron and causes planet Earth to be magnetic, we say it has a magnetic field around it. Not all planets have magnetic fields; the pie chart compares the planets in our solar system that have and have not got magnetic fields.

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How many planets in the solar system have magnetic fields?