WHAT DOES YOUR SHADOW ON THE EQUINOX TELL YOU?

Equinoxes occur twice a year—20th March and 23rd September. On these days, the sun's rays falling on the earth are perpendicular to the earth's axis. Thus, the duration of day and night is nearly equal.

On these days, you can find out many things about the earth using observations and calculations, including the minimum shadow length, local noon, North (and other directions), latitude, and longitude at your location. These activities will show you how.

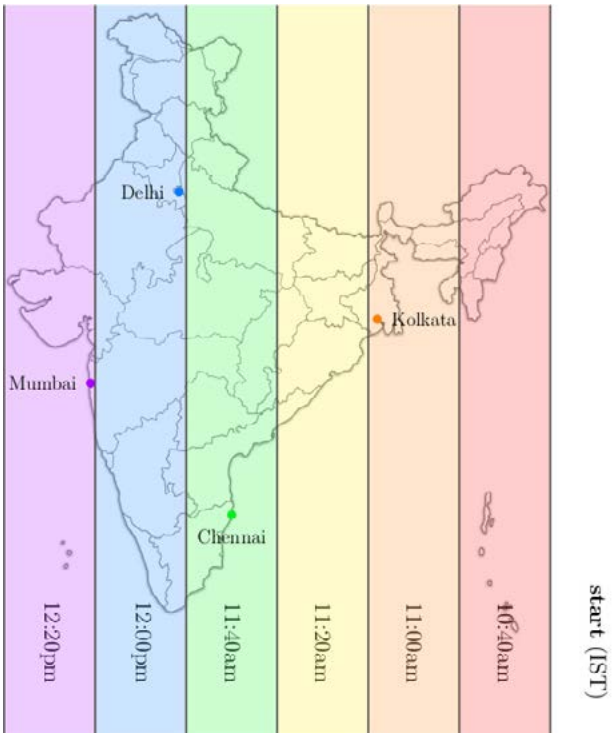

Fig. 1. When to start your experiment? Find your location on this map to decide when to start your experiment.

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You will need

Flat ground (with direct sunlight), a vertical object, and measuring tape.

What to do

1. Set up the experiment:

- Start your experiment by marking a point on flat ground (see **Fig. 1**). At this point, place a vertical object (with a height > 20cm), like a pipe, a stump, or yourself. This is your Gnomon (or a vertical stick that shows the time by the length and position of its shadow). Measure the height of the Gnomon (see **Fig. 2**).

Fig. 2. Measuring the height of your Gnomon.

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2. Observe and measure:

- Mark the tip of the shadow of your Gnomon on the ground.
- Measure the shadow length after every 10 minutes for a duration of 80 minutes.
- Additionally, measure the shadow length at 12 PM IST.

What can you find out?

a) Local noon: The local noon on any day is the time at which the sun is at its highest point in the sky and the shadows are the shortest. So finding the time when your shadow is the shortest will give you your local noon (you can verify your observation of local noon on the ZSD app, which is described in **Box 1**).

b) Directions (N, S, E, W): To do this, join the base of the Gnomon to the marking you made on the ground at local noon. This is the North-South line (an imaginary line forming a great circle that passes through the earth's North and South geographic poles). Once you mark this line, you

Box 1. Other resources:

(a) 'Zero Shadow Day' (ZSD) app: This is an Android smartphone app that contains a number of interactive visualisations to understand how shadows cast by the sun change over the course of a year at different places. It also provides data for users to examine. The app was commissioned by the Astronomical Society of India—Public Outreach and Education Committee (ASI-POEC). It can be accessed here: https://play.google.com/store/apps/details?id=com.alokm.zsd.

(b) ASI-POEC activities: These activities help explore and understand shadows:

- Zero Shadow Day: https://astron-soc.in/outreach/activities/zero-shadowday/.
- Equinox Shadows: https://astron-soc.in/outreach/activities/shadowsequinox/.
- December Solstice Shadows: https://astron-soc.in/outreach/activities/shadows-decemsolstice/.

(c) Classroom session about shadow lengths:

1. Where is My Shadow? Learning Unit, Vigyan Pratibha (HBCSE). URL: https://vigyanpratibha.in/index.php/where-is-my-shadow/.
2. A book of activities to explore the sun and shadows. Monteiro, V., Mahashabde, G., and Barbhai, P. (2008). Sun Earth Experiments: Activity Cards for Day-time Astronomy. Navnirmiti Learning Foundation. URL: https://navnirmitilearning.org/wp-content/uploads/2021/07/Sun-Earth-Experiments-Activity-Cards-for-Day-Time-Astronomy.pdf.

will observe that shadows will be to the west of it before local noon, and to the east of it after local noon. Remember: On the equinox, the sun rises exactly East and sets exactly West. So, if you observe the rising or setting point of the sun at the horizon, you can check if this agrees with the directions you found from your local noon shadow.

c) Latitude: Since the sun is overhead at the equator and its rays are perpendicular to the earth's axis, the angle made by these rays to any vertical object at local noon on equinox days is equal to its latitude. To find this out, draw a right triangle with the Gnomon's height and its minimum shadow length. Measure the angle at the top of this triangle (see **Fig. 3**). This angle is equal to your latitude!

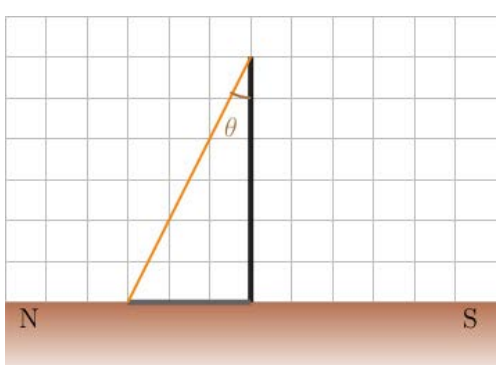

Fig. 3. Find out your latitude.

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d) Longitude: At any instant, different places on earth have different times of the day. The 24 hours of a day are evenly spaced around 360 degrees of longitude. So, 1 degree of longitude accounts for 4 minutes. The reference longitude at which IST is calculated is 82.5E (near Prayagraj). To find your longitude, calculate the time difference between local noon at IST and your local noon (see **Fig. 4**). This tells you how far you are from 82.5E. Then, use the following calculation:

Your longitude = 82.5E + (local noon at 82.5E - your local noon)*/4
Local noon at 82.5E on 20th March: 12:07**
Local noon at 82.5E on 23rd September: 11:52**
(* Taken in minutes
** This is not exactly 12 PM IST since there are some differences due to the "Equation of time". You can learn more about this on the ZSD app.)

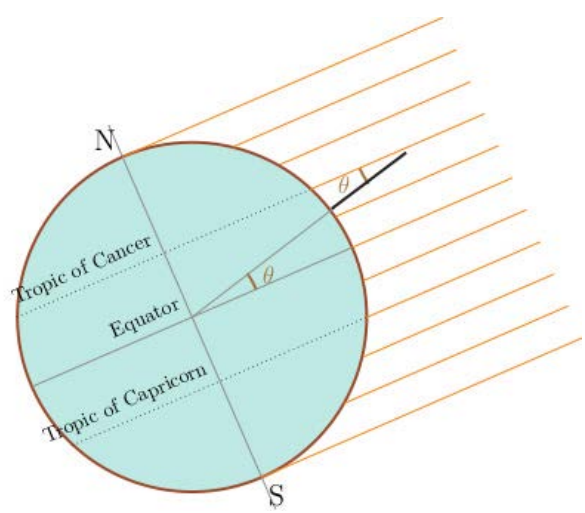

Fig. 4. Find out your longitude.

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What else?

To share your information with others, fill out a google form linked on the webpage: https://astron-soc.in/outreach/activities/shadows-equinox/.

Do you think that the data you and others have collected can be used to calculate other things, like the circumference of the earth or the rate of rotation of the earth? How would you go about it?

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Notes:

1. This snippet is based on a poster that was developed along with AIPSN and ASI-POEC for observation and measurements of the equinox: https://astron-soc.in/outreach/activities/shadows-equinox/.
2. Source of the image used in the background of the article title: Jigsaw pieces. Credits: Wounds_and_Cracks, Pixabay. URL: https://pixabay.com/photos/puzzle-piece-tile-jig-jigsaw-game-3306859/. License: CC0.

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