

## The Sextant

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The sextant is an instrument used to measure the altitude of heavenly bodies, or the horizontal angle of shore objects and also their vertical angle of height.

**Sextant Parts** Various types of sextants are made by different manufactures, but the principles are the same.

- The *frame* has three legs, and the sextant is stored in its box or on a horizontal surface.
- The *handle* is on the same side as the legs, and is for holding the sextant while in use. To take the sextant from the box, lift it by the frame with the left hand, then transfer it to the right hand and hold it by the handle.
- The *arc* is graduated in degrees from 0° to 125° “on the arc”, and 0° to 5° “off the arc”.
- The *telescope* or *prismatic* is used to sight the object. It might have an adjustment for correcting the error of collimation.
- The *index arm* is pivoted at the centre of the arc, and rotates freely along the arc with the arrow index mark pointing to the angle on the arc. At the other end of the arm is a *clamp*, used to unclamp the index arm from the arc so that the arm can be rotated.
- The *micrometer drum* is part of the index arm with the “minutes” scale; turning the drum will move the arm along the arc.
- The *micrometer vernier* is a graduation scale, located next to the micrometer drum scale, enabling the “seconds” to be read.
- The *index mirror*, mounted on the index arm, is used to reflect the object to the horizontal glass. A screw on the back allows for adjustment.
- The *index mirror shades* mounted in the front of the index mirror can be used to reduce the intensity of the sun’s light to protect the observer’s eyes.
- The *horizontal glass* is half mirror, half glass. The mirror reflects the image of the object from the index mirror; at the same time, the observer can sight the horizon or other object through the glass. The glass has two screws on the back for adjustments. The first screw, on the glass side, is used to adjust the perpendicular error. The second screw, on the back of the mirror side, is used to adjust the index error.

- The *horizontal shades* located in the front of the horizontal glass have the same purpose as the index mirror shades.

**Sextant Errors** There are two types of errors: **non-adjustable**, and **adjustable**.

***Non-Adjustable Errors***

- *Prismatic error or shade error*: the two faces of the shade glasses and mirrors are not paralleled.
- *Graduation error*: the graduation on the arc, micrometer drum or vernier is improperly cut or calibrated.
- *Centering error*: the index arm is not pivoted at the exact centre of the arc.

***Adjustable Errors***

- *Perpendicular error*: the index mirror is not perpendicular to the frame.
- *Side error*: the horizon glass is not perpendicular to the frame.
- *Index error*: the index mirror and horizon glass are not parallel to each other.
- *Collimation error*: the line of sight through the telescope is not parallel with the frame. This error can be adjustable or non-adjustable, depending on the model.

In the case of non-adjustable errors, the instrument must be replaced. For correct results from the sextant, the adjustable errors must be eliminated or minimized by the user. Both horizon and index glasses must be perpendicular to the frame, and they must be parallel to each other when the sextant is at zero. The collimation error might or might not be adjustable, but other remaining adjustable errors must be adjusted in the following order:

***1st Adjustment Perpendicular Error***

The perpendicular error is caused when the index mirror is not perpendicular to the frame.

- Bring the index arm to about between 35° and 40° on the arc.
- Hold the sextant horizontally, with the arc away from you.
- Look into the index mirror; you will see the image of the arc, and the true arc is also visible on the side.
- If the image and the true appear as a continuous line, then the glasses are perpendicular. If they are not, then adjust the screw at the back of the index glass until they coincide.

***2nd Adjustment Side Error***

The side error is caused when the horizon glass is not perpendicular to the frame. This error can be checked by two methods:

*By means of the horizon*

- Set the index arm and micrometer drum at zero.
- Hold the sextant horizontally; observe the horizon, and rock the sextant to one side of the vertical.
- If the true horizon and its image form a continuous line, then the horizontal glass is perpendicular to the frame. If not, then adjust the screw nearest to the frame on the back of the horizon glass until the true horizon and the image of the horizon coincide.

*By means of a star*

- Set the index arm and micrometer drum at zero.
- Hold the sextant vertically; observe any star, and rock the sextant slightly to one side of the horizontal.
- If the true and the image coincide, then no error. If not, then adjust the screw nearest to the frame on the back of the horizon glass until they coincide.

**3<sup>rd</sup> Adjustment  
Index Error**

This error occurs when the horizon and index glasses are not parallel to each other.

*By means of the horizon*

- Set the index arm and micrometer drum at zero.
- Hold the sextant vertically and observe the horizon.
- If the image and the true horizon appear as a straight line, then the two mirrors are parallel. If not, an index error is present. First, turn the micrometer drum until the true and the image of the horizon appear as a straight line, and take the reading. If the reading is less than 2 minutes, then record it as the index error and apply it in the calculation. If the error is excessive, then adjust the second screw on the back of the horizon glass until the image and the true horizon coincide.

*By means of a star*

- Set the index arm and micrometer drum at zero.
- Hold the sextant vertically, and observe the star. If the image appears above or below the true star, then conduct the error amount check in the same way as above before making any adjustment. The adjustment is made by turning the second screw on the back of the horizon glass.

The screw on the back of horizon glass is used to correct both side error and index error. After correcting the index error, the side error must be checked and re-corrected if necessary. It is difficult to remove both errors. However, if removing both errors proves impossible, then adjust to correct the side error, record the error and

apply it for correction in the calculation. The final index error can be found by holding the sextant vertically and observing the horizon or the star, then adjusting the micrometer drum until the horizon or star coincide. Take the reading to obtain it as the index error.

- If the error is greater than zero, the index error is said to be “*on the arc*” and must then be subtracted from all readings.
- If the error is less than zero, the index error is said to be “*off the arc*” and must then be added to all readings.

*By means of the sun*

This is probably the most accurate method of determining the index error. However, it requires a bit of calculation and checking of results.

Set the index arm and micrometer drum at zero, and observe the sun. If the image and the true sun do not coincide, an index error exists. There are two cases of calculating the error.

*Case 1*

The image and the true sun overlap, which means the index error is less than the diameter of the sun.

- Move the index arm and/or the micrometer drum until the upper limb of the image just touches the lower limb of the true sun; take the reading (x), and note whether it is on or off the arc.
- Move the index arm until the lower limb of the image touches the upper limb of the true sun; take the reading (y), and again note whether it is on or off the arc.
- The index error will be equal to half the difference between the two readings, and is named as the same as the greater reading.

$$\text{index error} = \frac{x-y}{2}$$

- To check the result: add two readings, and divide by 4. If the result equals half the diameter of the sun, which is obtained from Nautical Almanac for the day, then the index error is corrected.

$$\frac{d}{2} = \frac{x+y}{4} \quad \text{Where d is diameter of the sun}$$

*Case 2*

The image is not touching the true sun, which means the index error is greater than the diameter of the sun.

- Repeat the method as in case 1 to obtain two readings.
- The index error equals half the sum of two readings. Both

readings are either “on” or “off” the arc, and the index error is named accordingly.

$$\text{index error} = \frac{x+y}{2}$$

- For checking the accuracy of the result, divide the difference between two readings by 4; it should equal half the diameter of the sun, which is obtained from the Nautical Almanac for the day.

$$\frac{d}{2} = \frac{x-y}{4} \quad \text{Where } d \text{ is diameter of the sun}$$

#### ***4<sup>th</sup> Adjustment Collimation Error***

This error is present when the line of sight of the telescope is not parallel with the frame.

- Set the index arm near zero.
- Look through the index mirror while holding the sextant in such a position that the reflected image of the centre line and the horizon mirror is directly in line with the actual centre line.
- If you can see through the telescope, there is no error; if not, an error is present.
- If the adjustment tool is provided, then adjust it; otherwise, it has to be done by the manufacturer.