Positioning and Navigation Systems I (MSS 311)

Prof. Gamal El-Fiky

Maritime Studies Department, Faculty of Marine Science

King AbdulAziz University

_gamal_elfiky@yahoo.com_

- _Room No. 221_

Chapter 3

The Marine Magnetic Compass

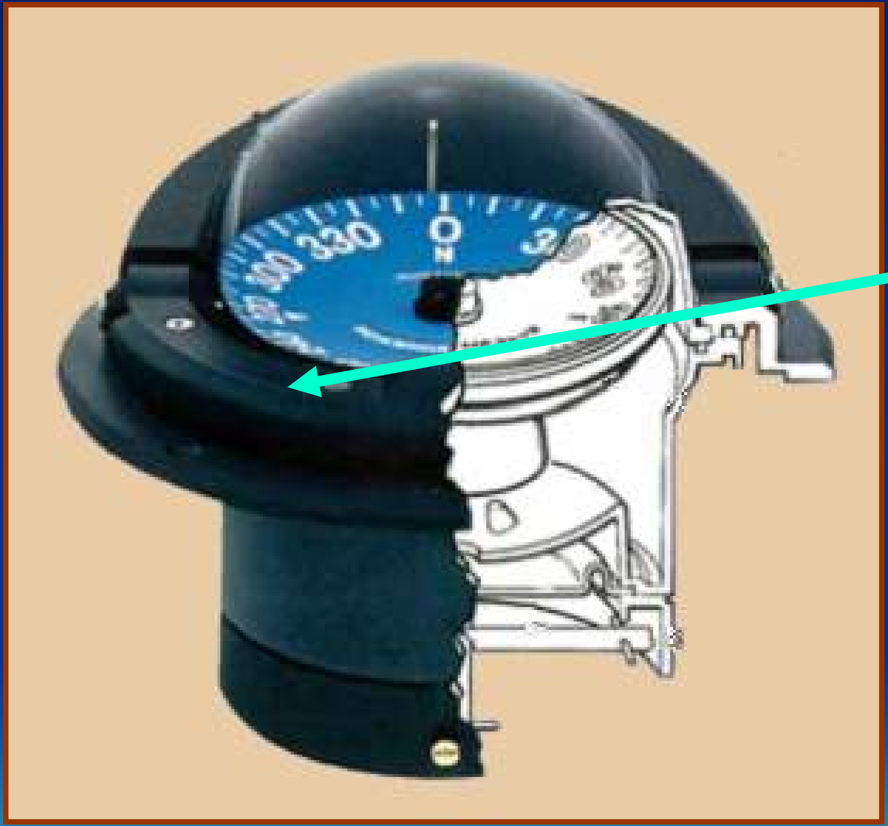
Magnetic Compass

- The magnetic compass still retains its importance despite the invention of the gyro-compass. While the latter is an extremely accurate instrument, it is relatively expensive, highly complex, dependent on an electrical power supply, and subject to mechanical damage.
- The magnetic compass is less expensive, entirely self-contained, fairly simple, and not easily damaged.

What We'll Cover

- Compass design
- Principles of operation
- Deviation & swinging ship
- Compass calculations

Parts of a Compass



Constructed of non-magnetic materials.

Parts of a Compass

Indexed card to read direction.

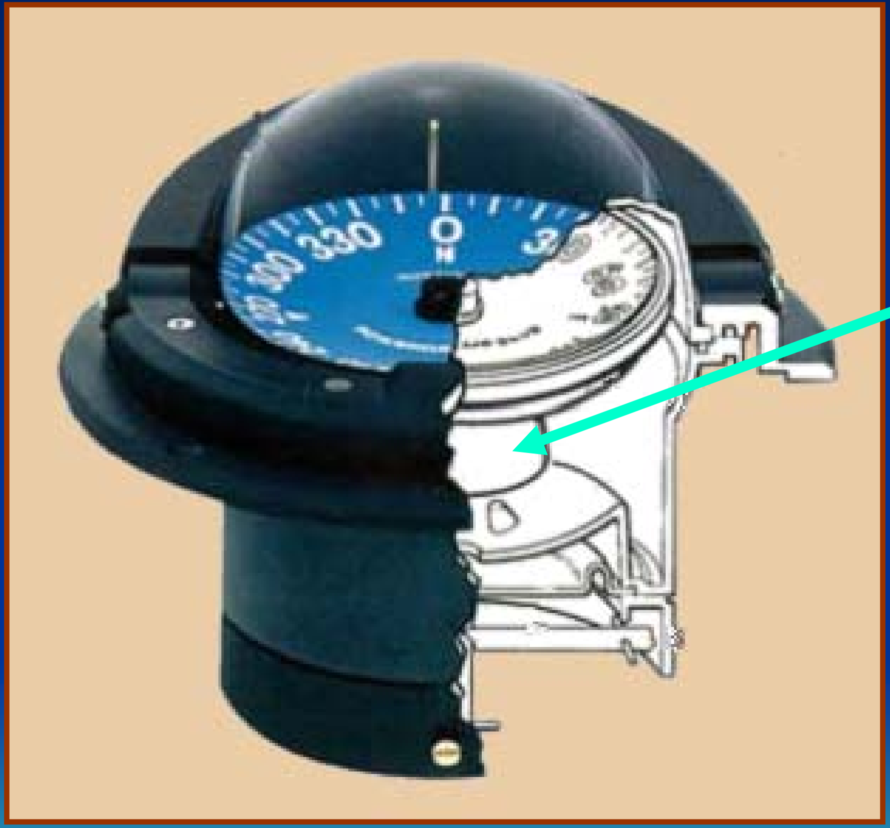
Parts of a Compass

Lubber line pins to align compass with boat.

Parts of a Compass

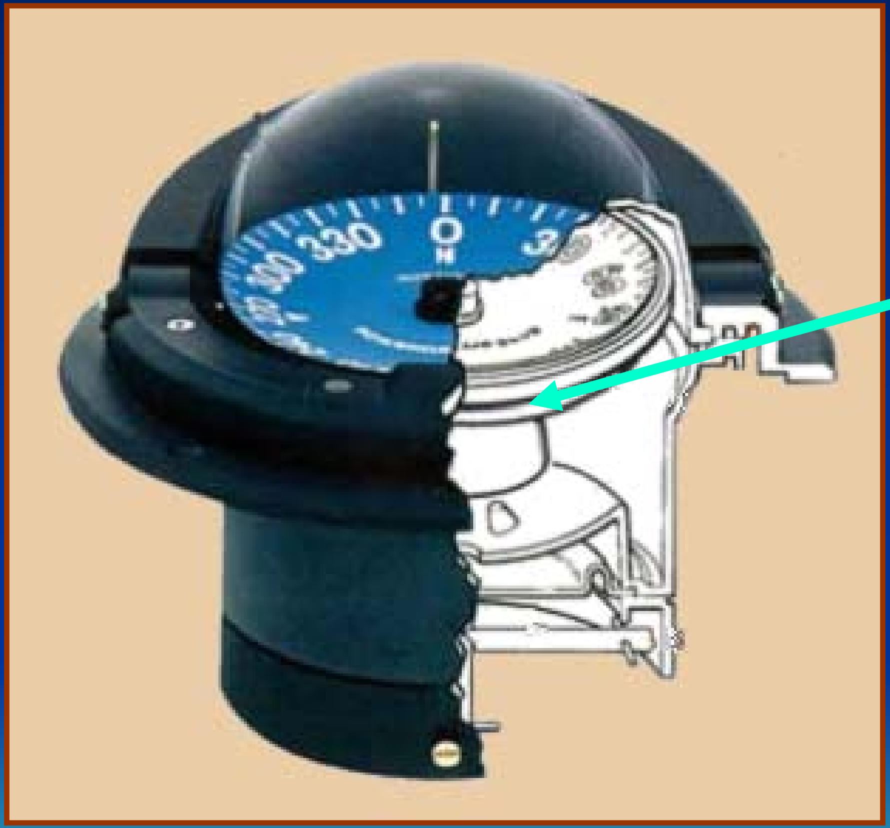
Gimbal system to keep card level when ship heels and pitches.

Parts of a Compass



Spherical bowl with expansion diaphragm.

Parts of a Compass



Fluid filled damping system to impede rapid card movement.

Parts of a Compass

Compensation system to reduce deviation error.

Steering Compass Styles

Top Reading Card

Usually used in binnacle steering stations.

Front Reading Card

Used when compass mounted on bulkhead.

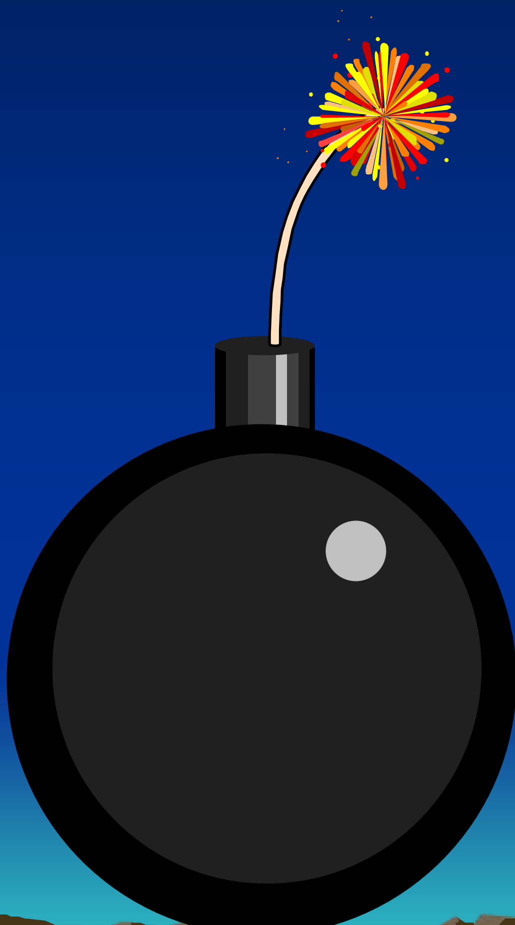
Hand Bearing Compass Styles

Front/Top Reading

Compass Card

- Graduated in degrees from 000 to 359.
- Graduated in 1, 2, 5 degree increments.
- Numbers spaced every 10-30 degrees.
- Usually show cardinal points: N, S, E & W.
- May show intercardinal points: NE, SE, SW & NW.

Compass Errors
Deviation and Variation



The unattractive Truth

…

Compasses <u>don't</u>

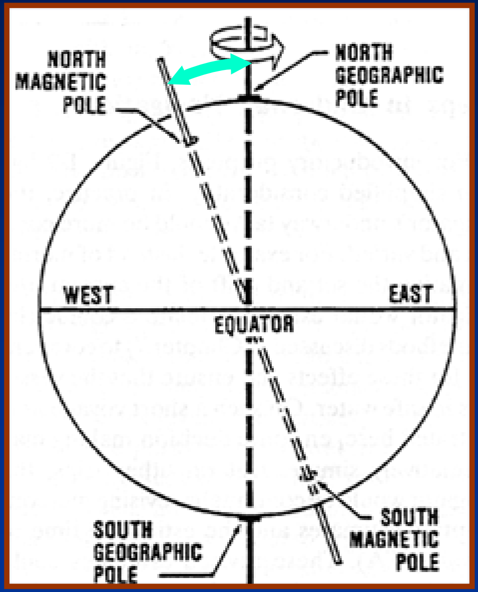
point to True North!

Compass Errors

- Variation: (Magnetic rose)

It is the difference at any location between the directions of the magnetic and true meridians.

  - Geographic (true) vs. magnetic north.
  - Common to all parts of the globe.
  - Identified on every chart's compass rose's.

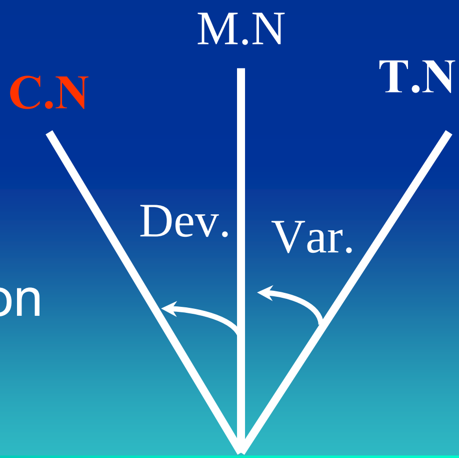


- Deviation: (From deviation tables)

It is the divergence between the N-S axis of the compass card and the magnetic meridian.

  - Caused by shipboard magnetic influences.
  - Exists on all vessels; different for each vessel.
  - It varies widely.

The Compass Errors: The algebraic sum of variation and deviation



Example:

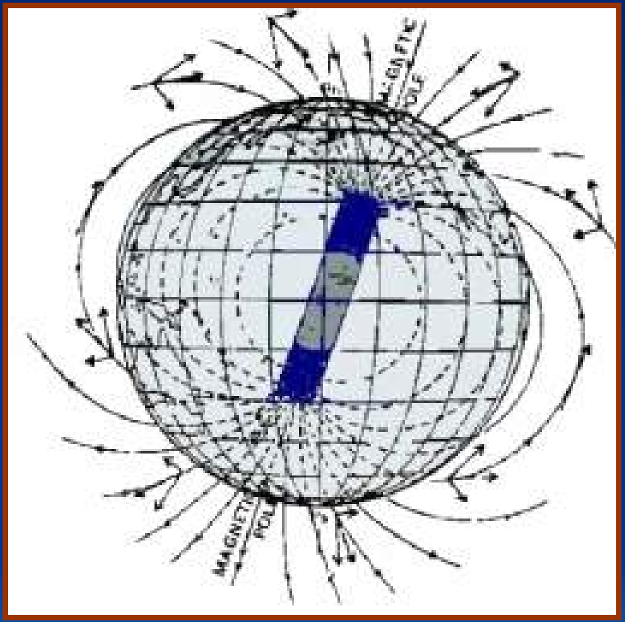
- If the variation was 05° 55‘ W (in 1979), decreasing about 4‘ annually, calculate variation in year 2008.

Solution:

 2008
 1979
 ______
 0029 years × 4‘=116‘= 01° 56‘
 Then: Var. (1979)= 05° 55‘ W
 -01° 56‘
 ______
 03°59‘ W

Variation: Earth - A Magnet

- Locating exact source of magnetism difficult.
  - Alignment of magnetism changes.
  - Strength of pull varies over earth.



Deviation Table (1)

Compass Course	Deviation	Compass Course	Deviation
000° C	4.0° E	180° C	3.1° E
010° C	3.0° E	190° C	2.2° E
020° C	2.0° E	200° C	0.6° E
030° C	0.4° E	210° C	2.0° W
040° C	1.2° W	220° C	3.2° W
050° C	2.2° W	230° C	4.4° W
060° C	3.0° W	240° C	5.6° W
070° C	4.2° W	250° C	4.0° W
080° C	5.4° W	260° C	3.4° W
090° C	4.3° W	270° C	2.1° W

Example (1)

- Find the deviation of course 217°.

Solution:

Compass C.	Deviation
210°	2.0° W
220°	3.2° W
10	1.2
03	X

Then Deference of Dev.= 3×1.2/(10)=0.36°

So, Deviation of Course 217° = 3.2-0.36 = 2.84°W

Examples (2 & 3)

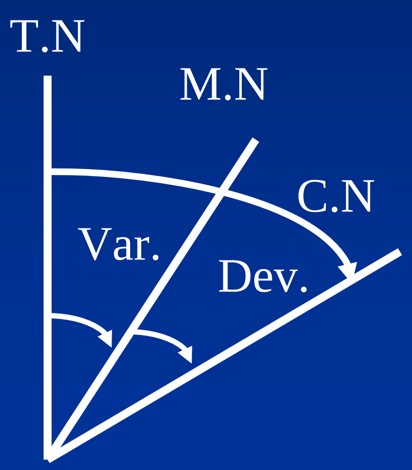
- If the variation is 3°E, and the deviation is 2°E. Calculate the compass error?

Solution:

Variation = 3°E

Deviation = 2°E

Compass error = ΣVariation + Deviation = 3 +2 = 5°E



- If the variation is 4°W, and the deviation is 2°E. Calculate the compass error?

Solution:

Variation = 4°W

Deviation = 2°E

Compass error = -4 + 2 = 2°W

Examples (4 & 5)

- If the C Bearing = 052°C, Var. 4°W and the Dev. = 1°E. Calculate True Bearing.

Solution:

Variation = 4°W
Deviation = 1°E
Compass error = 3°W

C. Bearing = 052°C
C. error = 3°W
T. Brg. =049°

- If the compass Bearing is 028°C, and the true Bearing is 025°T, Find the Compass error.

Solution:

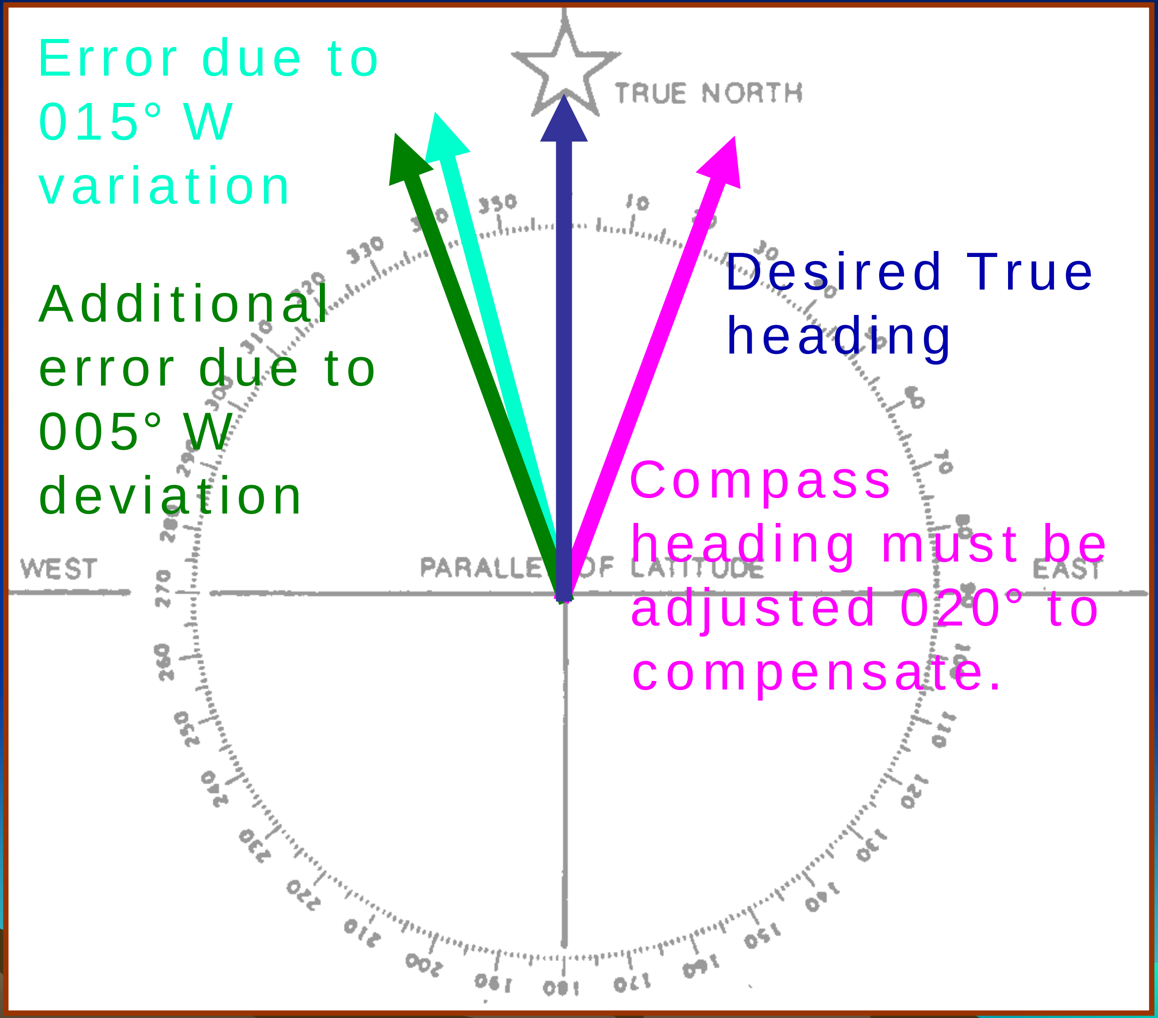
T. Brg. = 025°T
C. Brg. = 028°C
Compass error = 003°W

Note: (If C less than T the error is East and if C greater than T is West.

Deviation: Ship-Specific Error

- Due to on-board magnetic influences:
  - Magnetic items
  - Items to which magnets are attracted.
  - Wires carrying DC electrical current.
- Reduce effects as much as possible:
  - Keep compass away from influences
  - Twist nearby DC wire pairs.
- Usually can’t eliminate them all.

Additive Effect of Compass Errors

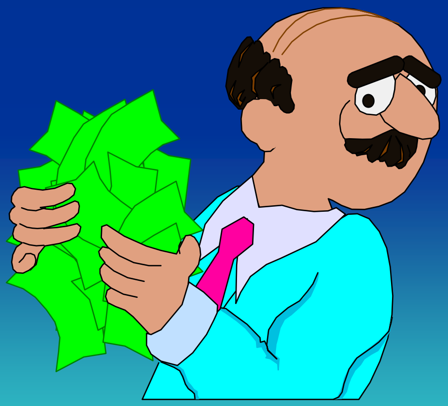


Measuring Deviation Yourself

- By using Deviation table or Curve we can obtain the deviation value of a specific Compass course.
- First you have to know how to do some compass calculations.

Compensation

- Deviation often greater than 10º.
- Special magnets (compensators) installed in compasses to <u>reduce</u> error.
- Most compasses come with instructions.
- Can still have significant deviation error after compensation.



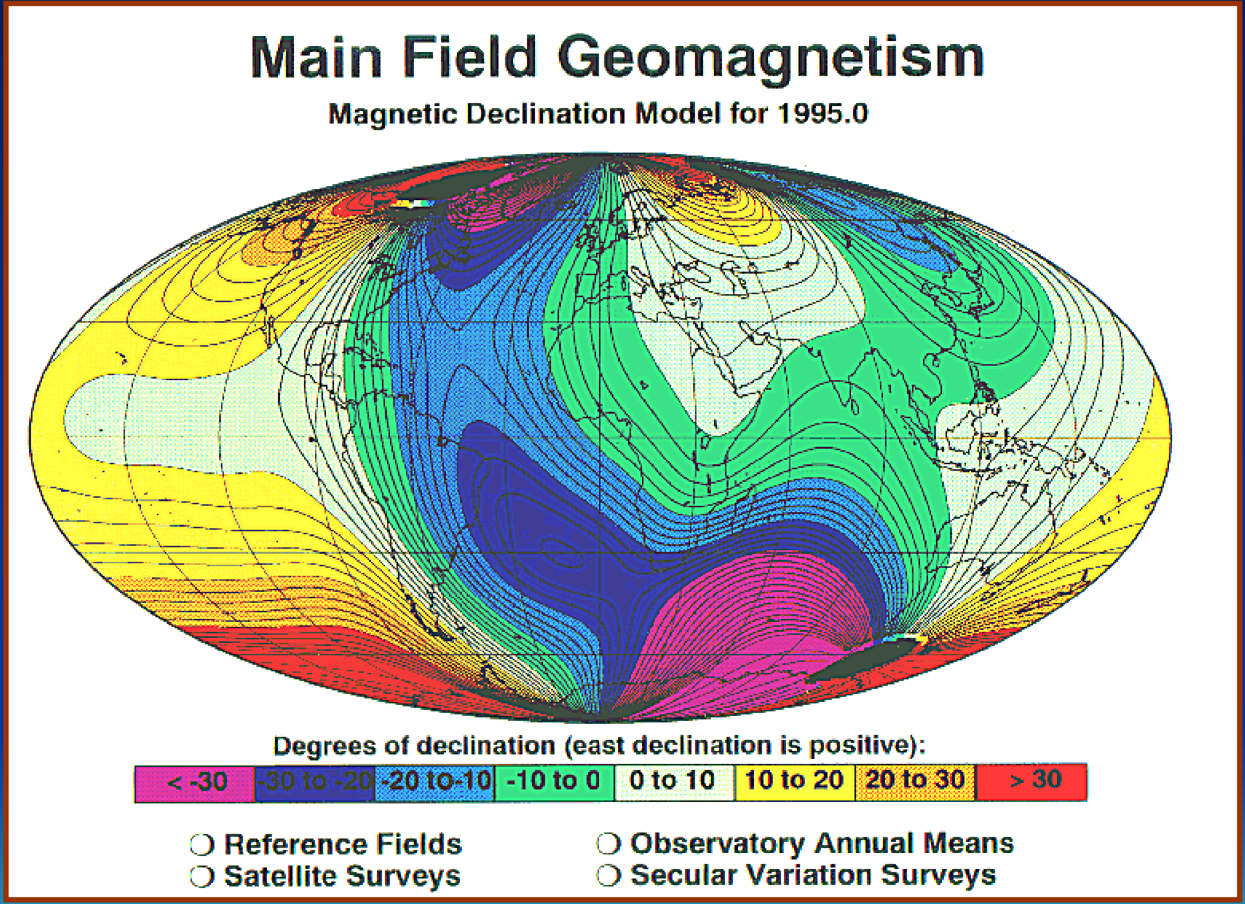
Computing Compass Corrections

+W

T	True Heading	**000**
V	Variation on Chart	**015 W**
M	Magnetic Heading	**015**
D	Deviation	**005 W**
C	Compass Course	**020**

World-Wide Variation

- Isogonic Chart
- Illustrates magnetic variation (1995)

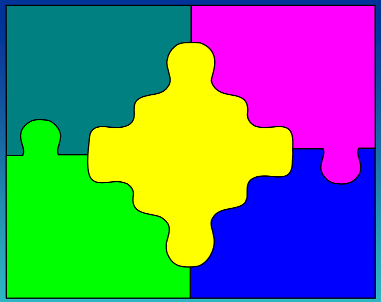


“Swinging Ship”

- Process of measuring residual deviation error after compensation.
- Usually determined in 15º - 30º heading increments.
- Recorded in form of deviation table.
- Compass adjuster can provide service.
- Or, you can do it yourself ...

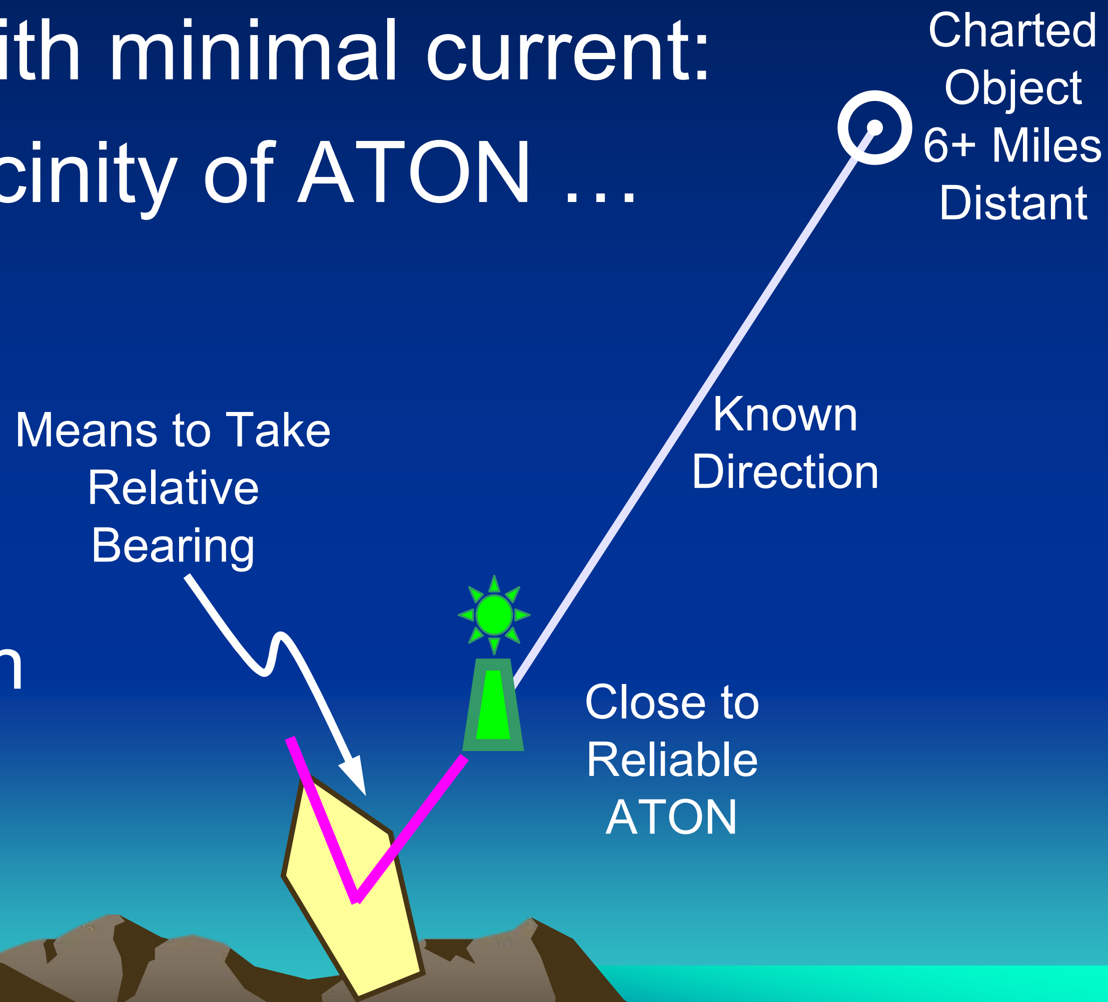
Back to Measuring Deviation

- For each 15º - 30º, you need to:
  - Know exactly what direction (magnetic) your boat is pointed.
  - Compare with compass reading.
  - Compute deviation.
- Key to puzzle is knowing exactly what direction you’re headed.
- There are several ways ...



Example Way to Know Your Heading

- In calm water with minimal current:
- Remaining in vicinity of ATON …
- Record both compass heading & relative bearing every 15° -- 30°.
- Compute deviation for each heading.



Measuring Relative Bearings

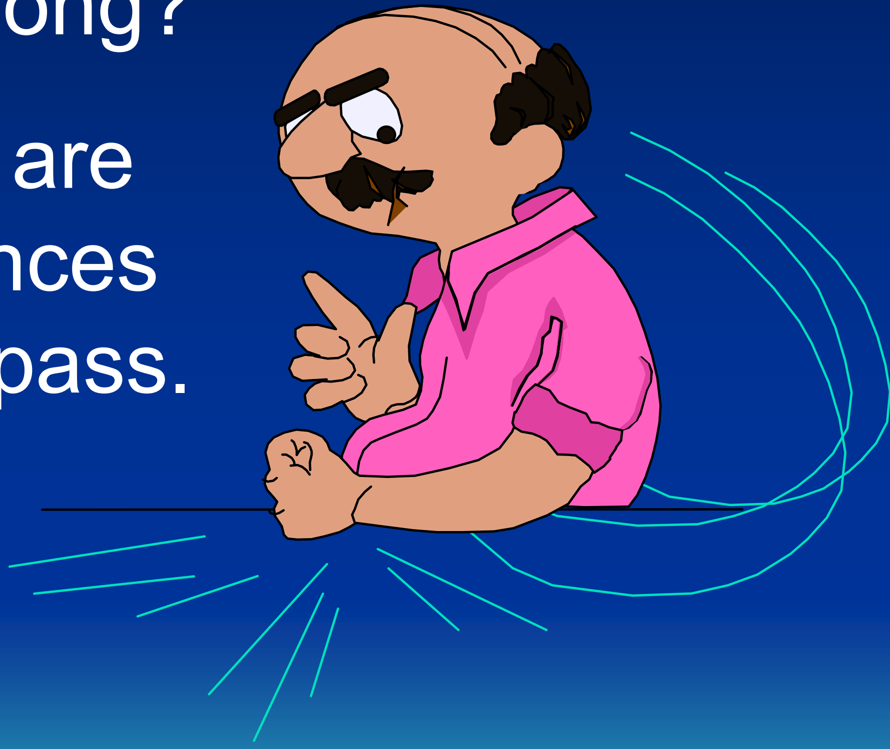
- Mounted parallel to vessel's keel with all-around view.
- 0º aligned with keel.
- Align targets in sights.
- Read relative bearing on scale.

Electronic Steering Compasses

Feature automated deviation elimination!

Local Magnetic Disturbances

- Compass <u>still</u> seems wrong?
- In some locations there are local magnetic disturbances that can affect you compass.
- Often noted on charts.



All this sound complex?

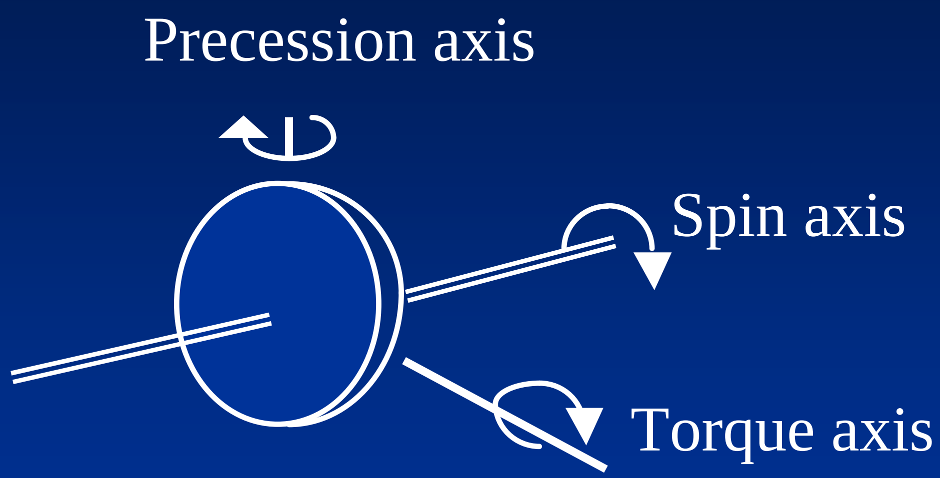
Perhaps, but the best solution is:

Practice ...

Practice ...

Practice!

Shipboard Compasses



–The gyrocompass has three axes: the *spin axis*, *torque axis*, *and precession axis.*

–As centrifugal force of the earth's rotation (tangential velocity), acts upon the gyro, the torque and precession axis will react, and keep the spin axis oriented to a terrestrial meridian.

Shipboard Compasses

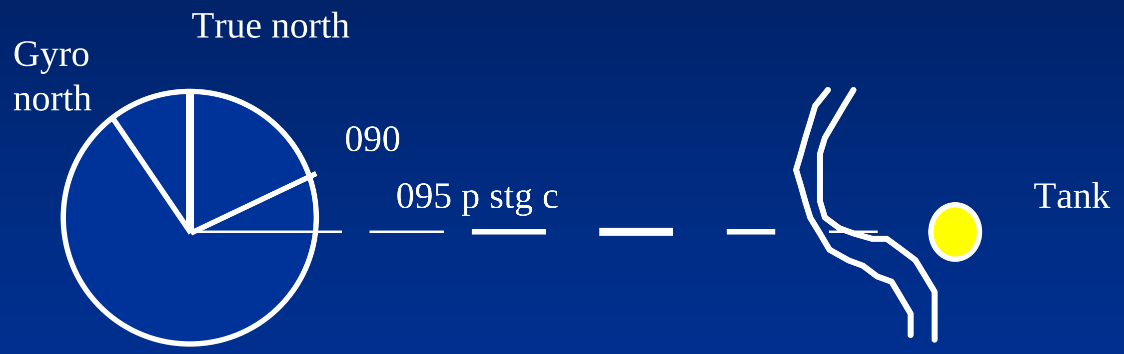
- The Gyro-compass (cont'd)
  - The gyrocompass has several advantages over the magnetic compass:
    - **It seeks true or geographic meridian instead of magnetic meridian.**
    - It can be used near the earth's magnetic poles, where the magnetic compass is useless.
    - It is not affected by surrounding material.
    - Its signal can be fed into inertial navigation systems, automatic steering systems, and fire control systems.
  - Being a complicated electronic instrument, the gyrocompass has some disadvantages
    - It requires a constant source of electrical power and is sensitive to power fluctuations.
    - It requires periodic maintenance by qualified technicians.

Shipboard Compasses

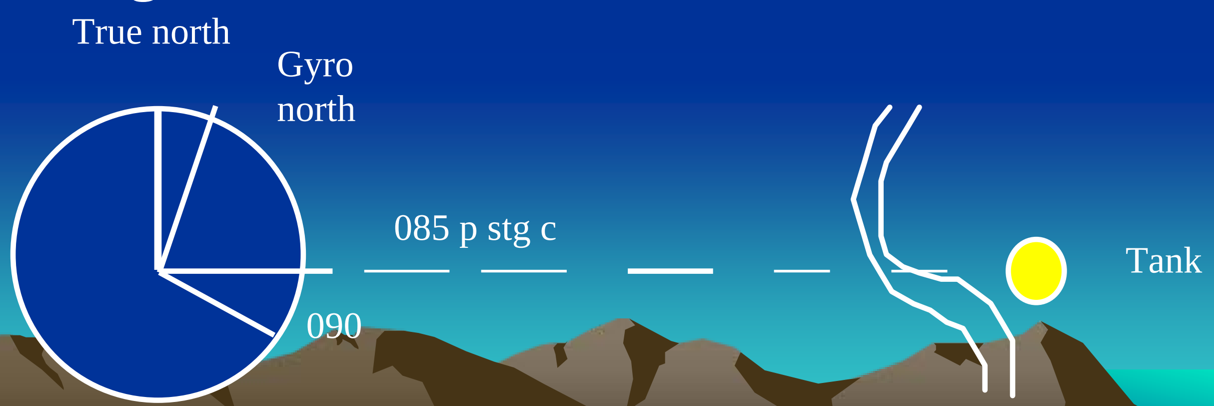
- Methods of determining gyrocompass error
  - Although the gyrocompass is a very accurate instrument and normally has a very small error associated with its readings (less than $.1^0$ to $.2^0$).
  - The navigator is required to determine gyro error at least once a day.
  - Gyrocompass error like magnetic compass error, is measured in degrees east or west

Shipboard Compasses

– If the gyrocompass bearing is higher than the actual bearing, the error is west



– If the gyrocompass bearing is lower than the actual bearing, the error is east



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