Q.9) Projections (Gnomonic/ Mercator)

1) You are planning a Great circle passage on your vessel. Explain the procedure for transfer of GC track from a Gnomonic chart to a Mercator chart.

Transferring GC Course to Mercator Chart

Transfer position along a Great Circle Track to Mercator Chart

On a gnomonic chart, the parallels of latitude are curved and the meridians of longitude are straight lines converging towards the pole. So a paralle ruler cannot be used to measure off position.

Gnomonic chats are ocean charts and the positions on them in terms of latitude and longitude is somewhat lacking as they are small scale charts.

- Draw the GC course as a straight line on the Gnomonic chart.
- Select meridians cutting the GC at suitable intervals of 5^0 or 10^0, and mark the points of intersection between the meridians and the GC.
- **For latitude:** Use a divider and read off the d'lat from nearest parallel marked on the chart. Take that to the eastern or western boundary of the chart and read off the latitude.
- **For longitude:** The straight lines are converging towards the poles. Use a divider and measure off the distance in millimetres between the nearest meridian on each side next to the position. Measure the distance in millimetres from the position to the nearest meridian and interpolate the value of longitude.
- Plot the latitudes and longitudes of each point of intersection on the Mercator chart and draw Rhumb lines by joining the points.
- The ship will sail along these Rhumb line courses, which is the closest representation of a GC course.

2) Discuss Mercator chart is a "Mathematical Projection" and not a Prospective Projection?

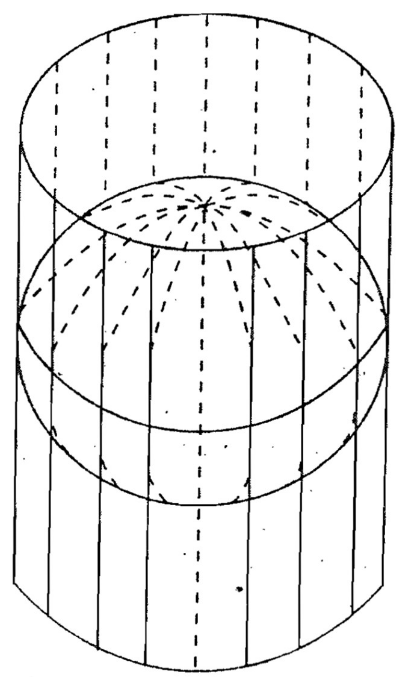
- Gerard Kermer = Latin name is Mercator.
- On a Mercator chart the parallels of latitude are horizontal parallel lines and longitudes are spaced parallel and in a vertical manner
- Meridians converge towards the poles but on the Mercator chart meridians are represented by equidistant parallel straight lines.
- Due to this the east-west distortion increases as latitude increases.
- Owing to this distortion and to maintain the orthomorphic property of a chart an equal north south distortion similar to the east-west distortions should increase Pole-ward.
- On the earth surface the east west distance between two meridians which is known as the departure
- Dep = d'long/ Cos lat i.e Dep = d'long X Sec Lat
- It shows the east-west distortion is directly proportional to the Sec of Lat
- This concludes that the Mercator chart is a Mathematical Projections and not a perspective one.

3.a) Describe Mercator Projection.

3.1 MERCATOR CHART

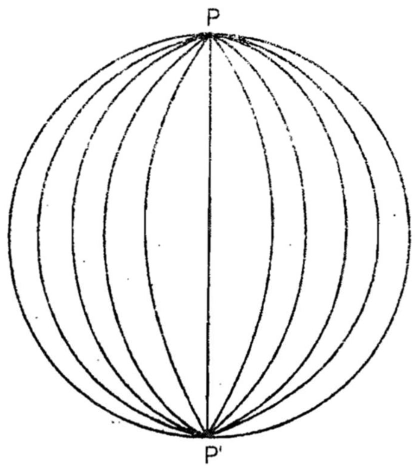
Most navigational charts are constructed on the Mercator projection, as they fulfill the important needs of the navigator, as stated earlier. This projection was initially used by Gerard Kremer, the latin form of whose name is Mercator. Among cartographers, the Mercator projection is said to be a "Cylindrical Orthomorphic Projection". It is derived mathematically and is not a perspective projection in the geometric sense. Apart from being orthomorphic, the projection is also stated to be cylindrical as it fulfills the conditions for a cylindrical projection. In a cylindrical projection the meridians are represented by parallel straight lines at right angles to the Equator. They divide the Equator into 360 equal parts.

On a Mercator chart the Equator and parallels of latitude appear as horizontal parallel straight lines at selected distances from the Equator and from each other. The spacing between the parallels is selected on a mathematical principle designed to best satisfy the conditions the chart is intended to fulfill.

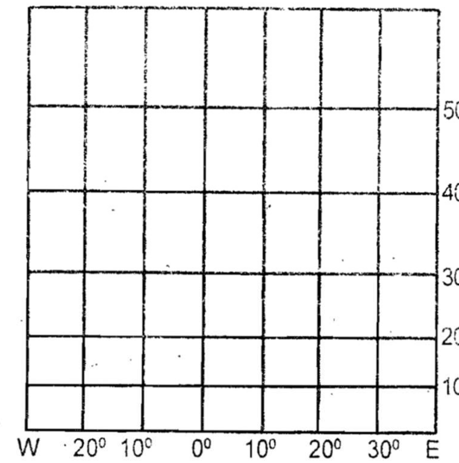


(FIG.3.1)

On the Earth's surface the meridians converge towards the poles. The distance between them is therefore maximum at the Equator and reduces as the latitude increases. On a Mercator chart however the meridians are represented by equidistant parallel straight lines. It therefore follows that the east-west distortion on the chart increases as the latitude increases.



(FIG.3.2)

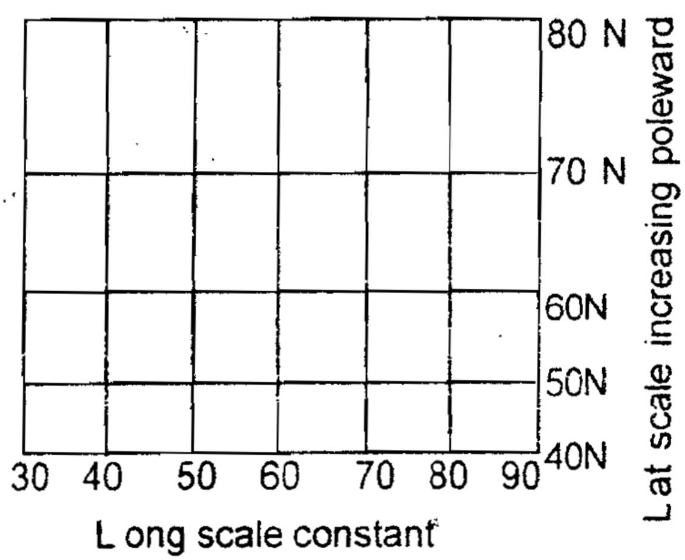


(FIG.3.3)

To maintain the orthomorphic property over the entire chart, it is therefore necessary to deliberately introduce an equal north-south distortion, which like the east west distortion should increase poleward. It can thus be seen that the distances between successive parallels of latitude on Mercator Chart will increase towards the pole.

On the Earth's surface the east-west distance between two meridians reduces as the cosine of the latitude, because the departure on any latitude is equal to the d'long multiplied by the cosine of that latitude. On a Mercator Chart however if the distance between the meridians is represented by x cm, at the Equator, it will be represented by the same x cm at all other latitudes also. Thus distortion on the chart at any latitude ϕ is equal to $x / x \cos \phi = \sec \phi$. Since the east-west distortion is proportional to the secant of latitude, the latitude scale should also vary as the secant of latitude to maintain the orthomorphic property. Since secant 0° is 1, it implies that at the Equator the latitude scale = longitude scale.In other latitudes,

Lat.Scale = Long. Scale x sec lat. The longitude scale on a Mercator chart is constant throug out the chart. Due to this, the distances and areas on a Mercator chart are exaggerated proportional to secant of latitude



ADVANTAGES OF A MERCATOR CHART

1. Rhumb line courses are easily laid off as straight lines
2. Distances are easily measured as scale of distances equal to scale of latitude
3. Shapes of land masses in the neighborhood of a point are correctly shown.
4. Angles between rhumb lines are unaltered between the earth and the chart
5. Directions remain correct though distortions of areas occur
6. Directions and position lines can be transferred correctly from one part of the chart to another as parallel lines. This facility is often used by a navigator for obtaining running fixes is not available in most other projections.

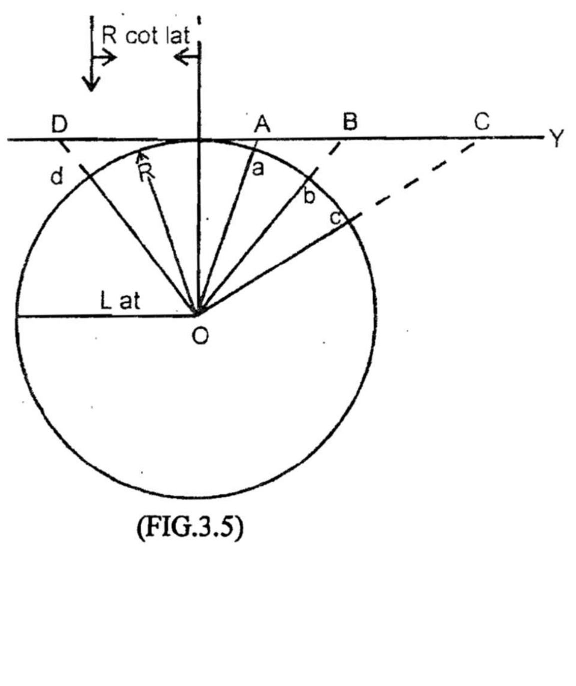
DISADVANTAGES OF A MERCATOR CHART

1. Great circle courses cannot be laid off easily as they would appear curved.
2. Polar regions cannot be represented due to extremely large distortions.
3. The scale of distance which is the scale of latitude is a varying unit.
4. Areas cannot be compared due to the varying distortion

3.b) What is Gnomonic Chart Projection? What are its advantages and disadvantages?

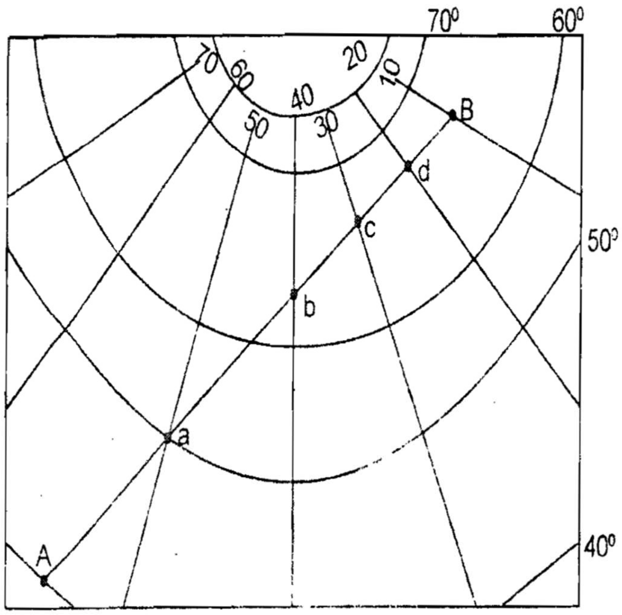
3.2 GNOMONIC CHART

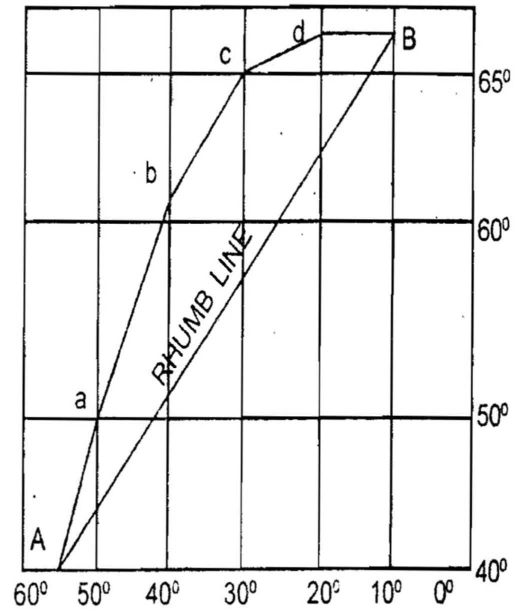
If a navigator is to follow the shortest route between two positions, he must sail along a great circle. It would therefore be convenient to have charts on which great circles are represented by straight lines. The Gnomonic chart has this property. It is constructed on the gnomonic or tangential projection. In this projection, all points on the surface of a sphere are projected from the centre of the sphere to a plane which is tangential to the sphere. The tangent point chosen is usually around the centre of the area to be represented.



(FIG.3.5)

As with any projection used, distortions will be present on a gnomonic chart. It can be seen from figure 3.5. that distortion is nil at the tangent point and increases as the distance from the tangent point increases. If the tangent point is one of the poles, the chart would be a polar gnomonic chart. On a gnomonic chart, all great circles appear as straight lines. Therefore, meridians appear as straight lines converging towards the poles. Small circles and rhumb lines appear curved. Compass roses are not shown on gnomonic charts as they would be valid only for that particular location, since meridians are convergent.





Gnomonic charts are used to plot great circle courses between the departure and arrival positions, as straight lines (Fig. 3.6). Positions are then taken off at convenient intervals of longitude along the track. These positions are then transferred to a Mercator chart and rhumb line courses are laid off between the successive positions (Fig. 3.7). By sailing along the various rhumb line courses, the ship would make a track which would approximate very closely to the actual great circle course, without having to change course continuously as would have been necessary, if following a true great circle.

ADVANTAGES OF GNOMONIC CHART

1. All areas of the world including Polar Regions can be represented on gnomonic charts.
2. Great circle courses are easily laid off as straight lines.

DISADVANTAGES OF GNOMONIC CHART

1. Rhumb line courses and bearings cannot be laid off easily as they appear curved.
2. Bearings and positions lines cannot be transferred from one part of the chart to another as parallel lines, because the meridians are convergent.
3. Measurement of distances and courses is difficult

4) Write a short note on UTM projection. (JULY 24, APRIL 24, SEPT 22, OCT 20)

THE UNIVERSAL TRANSVERSE MERCATOR SYSTEM

The projection used in this system is the transverse Mercator projection, therefore, all geographic parallel of latitude and all geographic meridians, except the geographic equator and the central meridian will appear curved.

UTM is a system of world co-ordinates (like latitude and longitude) covering the entire surface of the earth from 80° S to 84° N. The rectangular co-ordinates or measurement are in meters. The UTM lines are therefore at right angles to each other i.e. they are "orthogonal". UTM easting is the distance east, in meters from the chosen central meridian (transverse equator) of the area depicted. UTM northing is the distance north, in meters, from the geographic equator. Because the distortion increase away from the central meridian, UTM maps are made of zones, 6° wide in longitude. Sixty such maps of 6° wide zones in longitude are made to cover the entire world. UTM northing is devided into 8° high zones and are designated by letters C for the zone 80°S to 72° S, D for the zone 72° S to 64° S and so on to L for the zone 08° S to 00°. The equator is designated M. For areas in North latitude, the 8° high zones are designated from N for the zone 00° to 08° N to X for the zone 80° N to 84° N. the letters A, B and Y, Z are not used in this system as they are used for the universal polar system, in the polar regions.

Since UTM easting is the distance east in meters form the central meridians, places to the west of the central meridian would have had negative co-ordinates. To avoid this, a system of "false" easting is introduced by designating the central meridian of the area depicted as 500,000 instead of zero. Thus the easting co-ordinate of places, say 10m to the east of the central meridian would have an easting co-ordinate of 500,010. The easting co-ordinate of places 10m to the west of the central meridian would have an easting co-ordinate of 499,990. Thus the easting co-ordinates of all positions within the area (6° wide in longitude)

5) With suitable sketch describe the difference between Gnomonic and Transverse Mercator projection?

Gnomonic Projection	Transverse Mercator Projection
Plane – tangent at the center point.	Cylinder – tangential along a central meridian.
Distortion increases rapidly away from the center. Accurate only near the center.	Distortion minimized along the central meridian, increases gradually away from it.
Used for plotting great circle routes (shortest path between two points).	Used for large-scale mapping like topographic maps and navigation charts.
Straight lines radiating from the center.	Curved lines, except the central meridian which is straight.
Circles, becoming more distorted away from center.	Curved parallels; spacing is mathematically controlled.
Both area and shape distort quickly away from center.	Distortion is controlled, preserving shape near central meridian.
Used for plotting shortest routes, especially in ocean navigation.	Used for accurate mapping and navigation charts where scale consistency is important.
Limited, suitable for small areas around center.	Can cover larger areas, commonly used for national and regional maps.
Simpler geometry but impractical for large areas.	More complex but accurate for extended regions.

Summary

Gnomonic projection is best for plotting great-circle routes over short distances. It's accurate near the center but rapidly distorts further away.
Transverse Mercator projection is used for detailed mapping and navigation, preserving scale and shape near the central meridian over larger regions, though distortion increases with distance.

6) What is conformal property or orthomorphic property of a chart? Why is it required for charts used for navigational purposes? (JULY 24)

A chart is said to be conformal (also called orthomorphic) if it preserves angles locally. This means that at any point on the chart, the angles between intersecting lines, such as meridians and parallels, or between plotted courses and features, are represented correctly, just as they are on the earth's surface.

Key Characteristics:

- Shapes of small areas are preserved.
- Angles are accurate, even if scale varies from place to place.
- Compass bearings and courses appear as they are on the earth.

✅ Why is Conformal Property Required for Navigational Charts?

1. Accurate Course Plotting: Ships and aircraft navigate using bearings and courses. A conformal chart ensures that angles measured on the chart correspond to actual angles on the earth, making navigation and plotting accurate.

2. True Representation of Direction: Mariners rely on compass directions to steer a course. A conformal chart ensures that directions between points are not distorted, which is critical when following a route over long distances.

3. Local Shape Preservation: The coastal features, harbors, and obstacles must be represented realistically to safely maneuver around them. Conformal charts preserve the local shapes of these features, aiding in hazard avoidance.

4. Reliable Triangulation and Intersection: Navigators use bearings from multiple points to determine their position. Conformal charts guarantee that these bearings intersect at the correct location.

5. Standardization and Trust: Conformal charts are widely accepted and ensure consistency in navigation, which is especially important when different ships and aircraft use the same charts.

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