2025-05-30 GNAV Lecture 1

> Date & Time: 2025-05-30 17:37:25
> Location: [Insert Location]
> [Insert Title]
> `Earth navigation` `Geographic coordinates` `Aviation calculations`

Theme

This lecture covers fundamental concepts in Earth navigation and aviation, including the effects of runway length and elevation on takeoff, Earth's orbit and rotation, geographic coordinate systems, great circle routes, time zones, and calculation formulas for distance and bearings. It emphasizes the importance of precise navigation, understanding magnetic variation, and using correct units and reference systems in aviation operations.

Takeaways

1. Takeoff performance is affected by runway length and airport elevation.
2. The Earth orbits the Sun in 365.25 days.
3. The Earth's axis is tilted, causing seasonal changes.
4. Daylight duration varies with latitude and season.
5. The Earth rotates anticlockwise (from west to east) when viewed from above the North Pole.
6. The Earth's diameter is approximately 12,700 kilometers or 6,850 nautical miles.
7. The Earth is an ellipsoid, not a perfect sphere.
8. Latitude and longitude are used to define positions on Earth.
9. Latitude is measured from 0° at the equator to 90° at the poles.
10. Longitude is measured from 0° at Greenwich to 180° east and 180° west.

Highlights

- `"A line drawn as a Great Circle is always the shortest distance between two points."-- Speaker 1`
- `"You gained one day. Gained means plus one."-- Speaker 1`

Chapters & Topics

Takeoff Performance and Airport Elevation

> Takeoff performance is influenced by runway length and the amount of air (density) at the airport, which is affected by elevation. Higher elevation airports generally have worse takeoff performance due to thinner air.

- **Keypoints**
  - Runway length and air density are critical for takeoff.
  - High elevation airports have reduced performance.
  - Sea level airports offer better takeoff conditions.
- **Explanation**
  The discussion highlighted that at higher elevations, the air is thinner, which negatively impacts aircraft performance during takeoff. Longer runways may be required to compensate for this reduced performance.
- **Considerations**
- Always check airport elevation and runway length before planning takeoff.
- **Special Circumstances**
- If operating from a high elevation airport, ensure the aircraft's performance charts are consulted to determine required takeoff distance.

Earth's Orbit and Seasons

> The Earth travels around the Sun in an orbit that takes 365.25 days. The tilt of the Earth's axis causes seasonal changes, with the North or South Pole tilted toward the Sun at different times of the year.

- **Keypoints**
  - Earth's orbit duration: 365.25 days.
  - Axis tilt causes seasons.
  - Daylight duration varies with latitude and season.
- **Explanation**
  The lecture explained that the Earth's axis is inclined, leading to different hemispheres experiencing summer and winter at opposite times. The tilt also affects the length of daylight throughout the year.
- **Considerations**
- Understand the relationship between Earth's tilt and seasonal changes for navigation.

Earth's Rotation and Direction

> The Earth rotates anticlockwise (from west to east) when viewed from above the North Pole. This rotation causes the sun to rise in the east and set in the west.

- **Keypoints**
  - Earth rotates from west to east.
  - Sun rises in the east, sets in the west.
  - Rotation affects wind patterns, such as in the Atlantic Ocean.
- **Explanation**
  The rotation of the Earth is responsible for the apparent movement of the sun across the sky and influences global wind patterns.

Earth's Shape and Dimensions

> The Earth is not a perfect sphere but an ellipsoid, squished at the poles. The diameter is approximately 12,700 kilometers or 6,850 nautical miles at the equator.

- **Keypoints**
  - Earth is an ellipsoid, not a perfect sphere.
  - Diameter: 12,700 km or 6,850 nautical miles.
- **Explanation**
  The lecture clarified that the Earth's shape affects navigation and the calculation of distances.

Latitude and Longitude

> Latitude and longitude are coordinate systems used to define positions on Earth. Latitude is measured from 0° at the equator to 90° at the poles, while longitude is measured from 0° at Greenwich to 180° east and 180° west.

- **Keypoints**
  - Latitude: 0° (equator) to 90° (poles), measured north or south.
  - Longitude: 0° (Greenwich) to 180° east or west.
  - Degrees divided into 60 minutes, minutes into 60 seconds.
  - Coordinates are always given as latitude first, then longitude.
- **Explanation**
  The lecture provided detailed explanations and examples of how to read and write coordinates, emphasizing the importance of precision using minutes and seconds.
- **Examples**
  > Woodford Airfield near Manchester is at latitude 53° 20' 17" N, longitude 002° 08' 56" W.

  - Latitude is given first: 53° 20' 17" N.
  - Longitude is given second: 002° 08' 56" W.
  - Degrees of longitude use three digits because they range from 0 to 180.
- **Considerations**

- Always use the correct order: latitude first, then longitude.
- Use minutes and seconds for precision.
- **Special Circumstances**
- If precise location is required (e.g., for official exams), include minutes and seconds in coordinates.

World Geodetic System 1984 (WGS84)

> WGS84 is a reference ellipsoid model established in 1984, used for navigation and mapping. It accounts for the Earth's flattening at the poles.

- **Keypoints**
  - WGS84 is the standard for navigation charts.
  - Describes Earth's shape as an ellipsoid.
  - Established in 1984.
- **Explanation**
  The WGS84 model allows for accurate navigation and mapping by providing a standardized reference for Earth's shape.
- **Considerations**
- Use WGS84 as the reference for all navigation calculations.

Types of Lines on Earth's Surface

> Lines drawn on Earth's surface can be small circles, rhumb lines, or great circles. Small circles do not pass through Earth's center, rhumb lines cross all meridians at the same angle, and great circles pass through Earth's center and represent the shortest distance between two points.

- **Keypoints**
  - Small circles: do not pass through Earth's center (all parallels except equator).
  - Rhumb lines: cross all meridians at the same angle.
  - Great circles: pass through Earth's center; shortest distance between two points.
  - Equator and all meridians are great circles.
- **Explanation**
  The lecture used diagrams and examples (e.g., New York to Moscow) to illustrate the differences and importance of these lines in navigation.
- **Examples**
  > Distance from New York to Moscow: straight line is 8,910 km (5,536 miles), great circle route is 7,500 km (4,660 miles).

  - Great circle route is shorter due to Earth's curvature.

    - Flat Earth assumption would not yield correct distances.
- **Considerations**
- For shortest route planning, use great circle calculations.
- **Special Circumstances**
- If precise navigation is required over long distances, always use great circle routes.

Five Major Circles of Latitude

> The Earth is divided by five major circles of latitude: the Arctic Circle, Antarctic Circle, Tropic of Cancer, Tropic of Capricorn, and the Equator. The Arctic and Antarctic Circles are located at 66.5 degrees north and south of the equator, respectively. The Tropic of Cancer and Tropic of Capricorn are located at approximately 23.4 degrees north and south of the equator, respectively. The Equator is the only great circle of latitude.

- **Keypoints**
    - Arctic Circle: 66.5 degrees north
    - Antarctic Circle: 66.5 degrees south
    - Tropic of Cancer: approximately 23.4 degrees north
    - Tropic of Capricorn: approximately 23.4 degrees south
    - Equator: 0 degrees, only great circle of latitude
- **Explanation**
  The lecturer explains the positions and significance of the five major circles of latitude, emphasizing their specific latitudinal positions and the unique status of the Equator as the only great circle.

Great Circle and Small Circle

> A great circle is the shortest distance between two points on a sphere. When flying from point A to point B, following the great circle route ensures the shortest path. A small circle does not pass through the center of the sphere and is not the shortest distance.

- **Keypoints**
    - Great circle passes through the center of the sphere
    - Great circle is the shortest distance between two points
    - Small circle does not pass through the center
    - Flight routes often use great circles for efficiency
- **Explanation**
  The lecturer uses the example of flying from point A to point B to illustrate why the great circle route is the shortest. If a straight line is drawn that does not cross the center, it is a small circle and not the shortest path.

- **Examples**
  > If you're flying from one position to another (A to B), the route should follow the great circle to ensure the shortest distance. If you fly straight without considering the great circle, you may not cross the center, resulting in a longer path.

  - Identify the start and end points (A and B) on the globe.
  - Draw the great circle route passing through both points and the center of the Earth.
  - Compare with a small circle route, which does not pass through the center and is longer.
  - Conclude that the great circle is the shortest distance.

Earth's Hemispheres

> The Earth is divided into the Northern and Southern Hemispheres by the Equator. The axis of rotation runs from the South Pole to the North Pole, with the Equator exactly halfway between.

- **Keypoints**
  - Axis runs from South Pole to North Pole
  - Equator divides Earth into two hemispheres
  - Northern Hemisphere is above the Equator, Southern Hemisphere is below
- **Explanation**
  The lecturer reiterates the division of the Earth into hemispheres and the role of the Equator and axis in this division.

Navigation: True Track and Magnetic Track

> In navigation, both true track and magnetic track are important. The direction is measured clockwise from north and always expressed as a three-digit number between 000 and 359.

- **Keypoints**
  - Direction measured clockwise from north
  - Expressed as three-digit number (e.g., 313)
  - Not measured anticlockwise
  - Cardinal directions: North (360), East (090), South (180), West (270)
- **Explanation**
  The lecturer explains how to measure direction for navigation, emphasizing the use of three-digit numbers and the importance of measuring clockwise.

True North, Magnetic North, and Compass North

> True north is the direction to the actual North Pole. Magnetic north is the direction to the magnetic north pole, which is not at the same location as the true north pole. Compass north is the direction indicated by a compass, which is influenced by the Earth's magnetic field.

- **Keypoints**
    - True north: direction to the geographic North Pole
    - Magnetic north: direction to the magnetic north pole (near northern Canada)
    - Compass north: direction indicated by a compass
- **Explanation**
  The lecturer distinguishes between the three types of north, explaining their definitions and significance in navigation.

Magnetic Deviation and Variation

> Magnetic deviation is the difference between magnetic north and compass north. Magnetic variation is the difference between true north and magnetic north. Magnetic variation is not uniform across the Earth's surface and changes over time.

- **Keypoints**
    - Magnetic deviation: difference between magnetic north and compass north
    - Magnetic variation: difference between true north and magnetic north
    - Lines of equal magnetic variation are called isogons
    - Magnetic variation is not uniform
    - Magnetic variation changes over time (in northern Europe by approximately 7 to 15 minutes)
- **Explanation**
  The lecturer explains the concepts of deviation and variation, the use of isogons, and the temporal changes in magnetic variation, providing an example of coordinates.
- **Examples**
  > In northern Europe, magnetic variation changes by approximately 7 to 15 minutes over time. For example, a coordinate in Spain or northern Europe might be 40 degrees north, 20 degrees 17 minutes 20 seconds east.

    - Identify the location (e.g., 40 degrees north, 20 degrees 17 minutes 20 seconds east).
    - Note the magnetic variation at this location.
    - Understand that over time, the variation changes by 7 to 15 minutes in northern Europe.

Degrees, Minutes, and Seconds in Geographic Coordinates

> Geographic coordinates are expressed in degrees (°), minutes ('), and seconds ("), where degrees are drawn in a circle, minutes are expressed in one stroke, and seconds in two strokes. Coordinates are written as, for example, 40°17'7"N.

- **Keypoints**
  - Degrees, minutes, and seconds are used to specify precise locations on Earth.
  - Minutes and seconds are subdivisions of degrees: 1 degree = 60 minutes, 1 minute = 60 seconds.
  - Coordinates must always specify direction (N, S, E, W) to avoid ambiguity.
- **Explanation**
  The lecturer explained that degrees are drawn in a circle, minutes in one stroke, and seconds in two strokes. For example, a coordinate could be 40 degrees north, 17 minutes, 7 seconds. The direction (N, S, E, W) must always be specified to avoid confusion, such as between north-east and east.
- **Considerations**
- Always specify the direction (N, S, E, W) when writing coordinates.
- Be precise with the notation for degrees, minutes, and seconds.
- **Special Circumstances**
- If the direction is omitted, the coordinate may be misinterpreted (e.g., as north-east instead of north).

Direction and Bearings: True North, Magnetic North, Compass North

> Directions in navigation are measured as angles clockwise from a reference north: true north, magnetic north, or compass north. For example, 087M means 87 degrees measured clockwise from magnetic north.

- **Keypoints**
  - True north is the direction along Earth's surface towards the geographic North Pole.
  - Magnetic north is the direction a magnetic compass points, which varies from true north.
  - Compass north is the direction indicated by the compass, which may be affected by local magnetic variation.
  - Bearings are measured in degrees clockwise from the chosen north.
- **Explanation**
  The lecturer described how to measure direction from different north references. For example, to find the compass direction, measure clockwise from compass north to the path of the airplane. For magnetic direction, measure from magnetic north. The angle measured gives the bearing, such as 73 degrees for compass, 80 degrees for magnetic.
- **Considerations**

- Always specify which north (true, magnetic, compass) is being used.
- Use the correct reference when plotting or reading bearings.
- **Special Circumstances**
- If the reference north is not specified, the bearing may be misinterpreted.

Units of Distance in Aviation: Nautical Miles and Knots

> In aviation, distance is measured in nautical miles (NM), and speed in knots (nautical miles per hour). One nautical mile is defined as the distance corresponding to one minute of latitude on Earth's surface.

- **Keypoints**
  - Nautical miles are based on Earth's geometry: 1 minute of latitude = 1 nautical mile.
  - Statute miles and kilometers are not equivalent to nautical miles.
  - Knots (kt) are used for speed: 1 knot = 1 nautical mile per hour.
- **Explanation**
  The lecturer explained that nautical miles are used because they correspond to one minute of latitude. For example, the distance between 51°43'N and 51°44'N is one nautical mile. The distance between 51°N and 52°N is 60 nautical miles, since 1 degree = 60 minutes.
- **Examples**
  > The distance between 51°43'N and 51°44'N is one nautical mile. The distance between 51°N and 52°N is 60 nautical miles.

  - Identify the difference in latitude: 1 minute or 1 degree.
  - 1 minute difference = 1 nautical mile.
  - 1 degree difference = 60 nautical miles.
- **Considerations**
- Use nautical miles for aviation calculations.
- Understand the relationship between latitude and nautical miles.
- **Special Circumstances**
- If using longitude, the relationship with nautical miles changes due to Earth's curvature.

Departure Formula for Distance Calculation

> The departure formula calculates the distance between two points on the same latitude or between points with different latitudes using mean latitude. The formula is: Departure = Change in Longitude × Cosine of Latitude × 60 (for same latitude), or Departure = Change in Longitude × Cosine of Mean Latitude × 60 (for different latitudes).

- **Keypoints**
  - For same latitude: use the latitude value in the cosine.
  - For different latitudes: use the mean latitude (average of the two latitudes) in the cosine.
  - Change in longitude is the difference between the two longitudes, subtract if in the same hemisphere, add if crossing hemispheres.
  - The result is in nautical miles.
- **Explanation**
  The lecturer provided the formula and explained its use. For two points at 60°N, 20°W and 60°N, 10°W, the change in longitude is 10 degrees, cosine of 60° is 0.5, and multiplying by 60 gives the distance. For points at 40°N, 10°W and 50°N, 30°W, the mean latitude is (40+50)/2 = 45°, cosine of 45° is √2/2, and the change in longitude is 20 degrees. The formula gives the distance in nautical miles.
- **Examples**
  > Point A: 60°N, 20°W; Point B: 60°N, 10°W. Change in longitude: 10°. Cosine of latitude: 0.5. Departure = 10 × 0.5 × 60 = 300 nautical miles.

  - Identify coordinates: both at 60°N.
  - Calculate change in longitude: 20°W - 10°W = 10°.
  - Cosine of 60° = 0.5.
  - Multiply: 10 × 0.5 × 60 = 300 nautical miles.

  > Point A: 40°N, 10°W; Point B: 50°N, 30°W. Change in longitude: 20°. Mean latitude: (40+50)/2 = 45°. Cosine of 45° = √2/2. Departure = 20 × (√2/2) × 60 ≈ 848 nautical miles.

  - Identify coordinates: 40°N and 50°N.
  - Calculate change in longitude: 30°W - 10°W = 20°.
  - Mean latitude: (40+50)/2 = 45°.
  - Cosine of 45° = √2/2.
  - Multiply: 20 × (√2/2) × 60 ≈ 848 nautical miles.
- **Considerations**
- Use subtraction for change in longitude/latitude if in the same hemisphere, addition if crossing hemispheres.
- Use programmable calculators for calculations involving degrees, minutes, and seconds.
- Round answers to two decimals if required.
- **Special Circumstances**
- If change in longitude is zero (same longitude), the formula does not apply.
- If only latitude changes, a different logic/formula is needed.

Rules for Adding/Subtracting Longitude and Latitude Values

> When calculating the change in longitude or latitude, subtract the values if both points are in the same hemisphere. If the points are in different hemispheres (e.g., one west, one east), add the values.

- **Keypoints**
  - Same hemisphere: subtract values.
  - Different hemispheres: add values.
  - This applies to both longitude and latitude.
- **Explanation**
  The lecturer explained that if both points are in the same hemisphere (e.g., both west), subtract the longitudes. If one is west and one is east, add the values to get the total change.
- **Examples**
  > From 20°W to 20°E: change in longitude is 20 + 20 = 40°.

  - Identify hemispheres: one west, one east.
  - Add values: 20 + 20 = 40°.
- **Considerations**
- Always check the hemisphere before calculating the difference.
- Be careful with sign conventions when moving across the prime meridian or equator.
- **Special Circumstances**
- If traveling from west to east or north to south across the zero line, add the values.

Mean Latitude in Departure Formula

> When calculating the distance between two points with different latitudes, use the mean latitude (average of the two latitudes) in the departure formula.

- **Keypoints**
  - Mean latitude = (latitude1 + latitude2) / 2.
  - Use cosine of mean latitude in the formula.
  - If both latitudes are the same, mean latitude is just that latitude.
- **Explanation**
  The lecturer clarified that mean latitude is the midpoint between two latitudes. For example, between 60°N and 20°N, mean latitude is (60+20)/2 = 40°.
- **Examples**
  > Between 60°N and 20°N: (60+20)/2 = 40°.

  - Add the two latitudes: 60 + 20 = 80.
  - Divide by 2: 80 / 2 = 40°.
- **Considerations**
- Use mean latitude only when latitudes are different.

- If latitudes are the same, use that value directly.
- **Special Circumstances**
- If only one latitude is given (no change), mean latitude is that value.

Formulas for Departure and Latitude Changes

> There are two formulas for calculating departure: when changing latitudes, use the cosine of mean latitude; when traveling along latitudes, use the cosine of latitude. Applying both formulas to the same values is possible, but they serve different purposes.

- **Keypoints**
  - Cosine of mean latitude is used when changing latitudes.
  - Cosine of latitude is used when traveling along latitudes.
  - Both formulas should not be confused or misapplied.
- **Explanation**
  The instructor emphasized the distinction between the two formulas and encouraged students to try applying both to the same values for understanding.
- **Considerations**
- Do not confuse the two formulas; use the correct one for the situation.

Units of Distance and Conversion

> A nautical mile is slightly larger than a statue mile. One nautical mile equals 1.15 statue miles and 1.852 kilometers. For elevation, one foot equals 0.3 meters, and one meter equals 3.28 feet.

- **Keypoints**
  - Nautical mile > statue mile.
  - 1 nautical mile = 1.15 statue miles.
  - 1 nautical mile = 1.852 kilometers.
  - 1 foot = 0.3 meters.
  - 1 meter = 3.28 feet.
- **Explanation**
  The instructor clarified the differences and conversions between nautical miles, statue miles, kilometers, feet, and meters, emphasizing the importance of using the correct units in aviation.
- **Considerations**
- Always use nautical miles in aviation unless otherwise specified.

Time Zones: UTC, Zulu, GMT

> In aviation, UTC (Coordinated Universal Time) or Zulu time is used. UTC is based on atomic clocks, while GMT is based on Earth's rotation, but for practical purposes, they are considered the same. The UTC framework is based on the prime meridian at Greenwich.

- **Keypoints**
  - UTC and Zulu are the same in aviation.
  - GMT is often used interchangeably with UTC.
  - Local mean time is calculated based on UTC offset.
- **Explanation**
  Examples were given for calculating local mean time in different countries by adding or subtracting the UTC offset. For instance, Spain is UTC+2, Turkey is UTC+3, Dallas is UTC-6.
- **Examples**
  > If the time in the UK is 11:15 UTC and Dallas is UTC-6, then Dallas local mean time is 11:15 - 6 hours = 5:15.

  - Identify the UTC time.
  - Subtract the local offset (for Dallas, -6).
  - Result: 5:15 local mean time in Dallas.
  > If the time in Greenwich is 16:45 UTC and Istanbul is UTC+3, then Istanbul local mean time is 16:45 + 3 = 19:45.

  - Identify the UTC time.
  - Add the local offset (for Istanbul, +3).
  - Result: 19:45 local mean time in Istanbul.
- **Considerations**
- Always confirm the UTC offset for the location.
- Be aware of daylight saving time changes.

International Date Line and Date Changes

> Crossing the International Date Line results in gaining or losing a day. Crossing from west to east means losing one day; crossing from east to west means gaining one day.

- **Keypoints**
  - West to east: lose one day.
  - East to west: gain one day.
  - Date changes are significant for flights crossing the dateline.
- **Explanation**
  Examples included flights departing Los Angeles on 31st December 2025 and

arriving in Auckland on 1st January 2026, gaining a day due to crossing the dateline.

- **Examples**
  > A flight departs Los Angeles on 31st December 2025 and arrives in Auckland on 1st January 2026, gaining a day.

  - Flight departs on 31st December 2025.
  - Crosses the International Date Line.
  - Arrives on 1st January 2026, one day ahead.
- **Considerations**
- Be careful with date calculations when planning flights across the dateline.
- Understand the direction of travel to determine if you gain or lose a day.
- **Special Circumstances**
- If encountering confusion about gaining or losing a day, remember: west to east loses a day, east to west gains a day.

Apparent Time vs. Standard Time

> Apparent time is based on the position and angle of the sun in the sky, while standard time is based on artificial frameworks like UTC and time zones. Daylight saving time is an additional adjustment.

- **Keypoints**
  - Apparent time is not used in aviation.
  - Standard time is based on UTC and time zones.
  - Daylight saving time may apply in some countries.
- **Explanation**
  The instructor noted that apparent time is for general knowledge and not used in aviation. Standard time and daylight saving time are more relevant for calculations.
- **Considerations**
- Check if daylight saving time applies in the country.
- **Special Circumstances**
- If encountering a country with or without daylight saving time, verify the current time adjustment.

Sunrise, Sunset, and Civil Twilight Definitions

> Sunrise and sunset are defined by the position of the sun relative to the visible horizon. Civil twilight is the period when the center of the sun is 6 degrees below the sensible horizon.

- **Keypoints**
  - Sunrise: when the top of the sun rises above the visible horizon.

    - Sunset: when the top of the sun disappears below the visible horizon.
    - Morning civil twilight starts when the center of the sun is 6 degrees below the sensible horizon and ends at sunrise.
    - Evening civil twilight starts at sunset and ends when the center of the sun is 6 degrees below the sensible horizon.
- **Explanation**
  The instructor explained the definitions and the importance of knowing the exact moments for sunrise, sunset, and civil twilight, especially for aviation operations.
- **Considerations**
- Remember the 6 degrees below the horizon for civil twilight.

Sensible Horizon and Visible Horizon

> The sensible horizon is the horizon measured with a flat ruler tangential to the Earth's surface. The visible horizon is what is actually seen, and at higher altitudes, the visible horizon extends further.

- **Keypoints**
    - Sensible horizon: theoretical, measured with a flat ruler.
    - Visible horizon: what is seen by the observer.
    - At higher altitudes, the visible horizon is farther away.
- **Explanation**
  The instructor used diagrams and explanations to differentiate between the two types of horizons.

Daylight Saving Time (DST)

> Daylight saving time is an adjustment of standard time, used in some countries. Not all countries observe DST.

- **Keypoints**
    - DST is not universal.
    - Spain, England, Italy, and Ireland observe DST.
- **Explanation**
  DST is more relevant in phase two of training, where calculations may involve DST tables.
- **Considerations**
- Check if DST applies in the country of operation.
- **Special Circumstances**
- If encountering a country without DST, do not apply DST adjustments.

Assignments & Suggestions

- Remember the two departure formulas for the exam: one for same latitude, one for different latitudes (using mean latitude).