Position Fixing. (Terrestrial navigation).

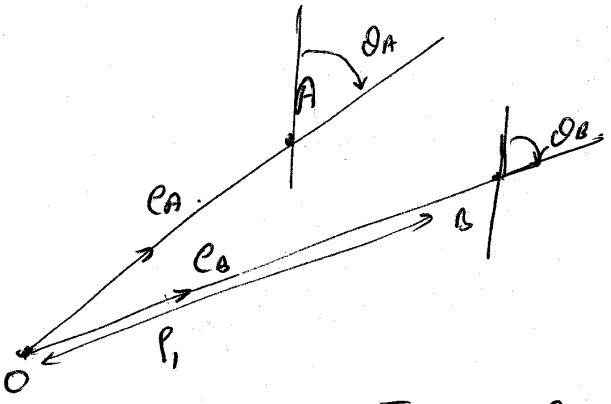
1) Using two bearing measurements.

True bearing - measured from the true meridian

Magnetic bearing - measured from the magnetic meridian

Relative bearing - measured from the vehicle axis.

The LOP of each measurement is a straight line.



$\bar{e}_A = \sin\theta_A \hat{i} + \cos\theta_A \hat{j}$ $\quad \bar{e}_B = \sin\theta_B \hat{i} + \cos\theta_B \hat{j}$.

$\bar{r} = \bar{r}_A - \rho_1 \bar{e}_A = \bar{r}_B - \rho_2 \bar{e}_B$

$\therefore \quad (\cos\theta_A \hat{i} - \sin\theta_A \hat{j}) \cdot \bar{r} = (\quad) \cdot \bar{r}_A$

$(\cos\theta_B \hat{i} - \sin\theta_B \hat{j}) \cdot \bar{r} = (\quad) \cdot \bar{r}_B$

$$\begin{bmatrix} \cos\theta_A & -\sin\theta_A \\ \cos\theta_B & -\sin\theta_B \end{bmatrix} \begin{bmatrix} \rho_1 \\ \rho_2 \end{bmatrix} = \begin{bmatrix} \quad \end{bmatrix}.$$

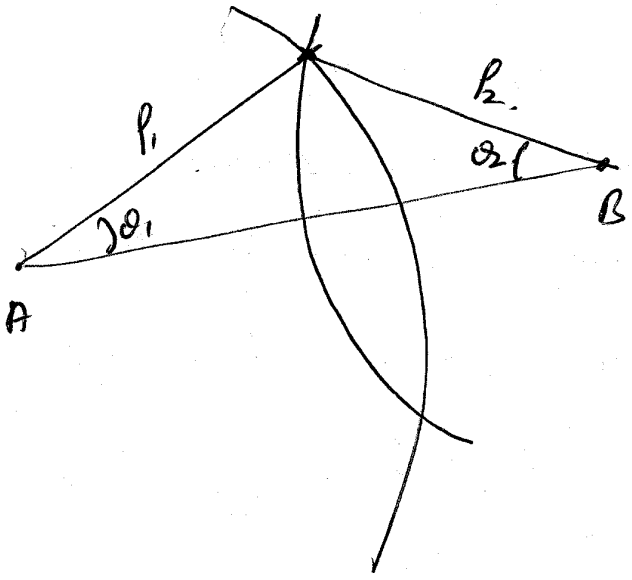
$\det = -\sin(\theta_B - \theta_A)$.

- for minimum error, need $\theta_B - \theta_A \simeq 90°$.

Explain VOR

VHF omnidirectional range.

2) Using distances from 2 points:



Each range measurement gives a circle as an LOP.

$\rho_1 \cos\theta_1 + \rho_2 \cos\theta_2 = |\bar{r}_A - \bar{r}_B|$.

$\rho_1 \sin\theta_1 = \rho_2 \sin\theta_2$.

Solve for θ_1 (or θ_2). – 2 values.

Then $\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} x_A \\ y_A \end{bmatrix} + \frac{\rho_1}{|\bar{r}_A - \bar{r}_B|} \begin{bmatrix} \cos\theta_1 & -\sin\theta_1 \\ \sin\theta_1 & \cos\theta_1 \end{bmatrix} \begin{bmatrix} x_A - x_B \\ y_A - y_B \end{bmatrix}$.

~~$|\bar{r}_A - \bar{r}_B|$.~~

Range measured using ~~time & reflection~~

for a sound wave (SONAR)
radio wave (RADAR)
light wave (laser ranging)

EXPLAIN DME

either by using the time of travel (runtimes)
or phase measurement. (partial information)

(4)

Bearing measurement in radio navigation (Powell, Hofmann-Wellenhof)

(1) VHF Omnidirectional Range: (108–118 MHz with channels spaces at 50 kHz)

Principle: Analogous to a lighthouse which emits an omnidirectional flash every time a continuous rotating directional beam points north. An observer will see two flashes. By timing the interval between the two flashes and knowing the speed of the rotating beam, an observer can find his bearing relative to the lighthouse.

In practice, a rotating dipole pattern is ~~amplitude~~ modulated by a 30 Hz signal to get a rotating cardioid pattern, which is received by an observer as a AM signal. The same signal is also frequency modulated by a 30 Hz signal. The received signal is an AM & FM detector yields two signals. The FM signal has the same phase irrespective of the observers location. While the phase of the AM signal depends on the bearing. The phases are arranged such that the variable phase AM signal lags the ref. phase FM signal by an amount = the magnetic bearing of the observer as seen by the VOR station.