FLYING A COURSE WILL WITHOUT WIND CORRECTION WILL RESULT IN VARIANCE FROM TC (1-2-3 ABOVE). IF WINDS CHANGE (INCREASE) AFTER T-O, THEN YOU MUST ADJUST FOR NEW WINDS TO INTERCEPT AND HOLD YOUR COURSE LINE FOR BOTH NON-AND RADIO NAV.
VISUAL AND RADIO NAVIGATION

DEAD RECKONING: THIS IS THE MODE WE HAVE BEEN USING TO CALCULATE AND FLY THE CALCULATED COURSE. IT DOES NOT EMPLOY RADIO NAVIGATION. REAL X-C INVOLVE BOTH THE USE OF YOUR CALCULATED COURSES AND THE USE OF RADIO NAVIGATION AIDS. BOTH REQUIRE FILING, OPENING AND CLOSING A VFR FLIGHT PLAN.

CRUSING ALTITUDES:  ODD +500 (3500-17,500 on course 0-179)  
EVEN +500 (4500-16,500 on course 180-359).
VISUAL AND RADIO NAVIGATION

VOR NAVIGATION

Very High Frequency Omnidirectional Range

(VOR) is LINE OF SIGHT.

Type VOR found in A/FD

Normal Usable Altitudes and Radius Distances

<table>
<thead>
<tr>
<th>Class</th>
<th>Altitudes</th>
<th>Distance (Miles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T</td>
<td>12,000’ and below</td>
<td>25</td>
</tr>
<tr>
<td>L</td>
<td>Below 18,000’</td>
<td>40</td>
</tr>
<tr>
<td>H</td>
<td>Below 14,500’</td>
<td>40</td>
</tr>
<tr>
<td>H</td>
<td>Within the conterminous 48 states only, between 14,500’ and 17,999’</td>
<td>100</td>
</tr>
<tr>
<td>H</td>
<td>18,000’ – FL 450</td>
<td>130</td>
</tr>
<tr>
<td>H</td>
<td>FL 450 – 60,000’</td>
<td>100</td>
</tr>
</tbody>
</table>

Generally, range of signal at 1,000 AGL is about 40 – 45 nm and increases with altitude.
VISUAL AND RADIO NAVIGATION

NAV NOT ALWAYS SHOWN (on airport)

Since the Salinas VORTAC is located on the field at Salinas Airport, an airport symbol appears in place of the VORTAC symbol at the center of the compass rose, and the word VORTAC appears at the top of the navigation box.

VICTOR AIRWAYS COURSE

V-111 is defined by the Salinas 167° radial and Big Sur’s 348° radial. Additional airways from Salina are defined by the 068°, 083°, 107°, 114° and 124° radials.

“COMPASS ROSE” (magnetic)

Big Sur VORTAC is depicted using a VORTAC symbol at the center of the compass rose.

Sectional: VOR Frequency and Morse Code for VOR
VISUAL AND RADIO NAVIGATION

VOR COCKPIT EQUIPMENT

TRANSCIEVER (COMM ON LEFT, NAV ON RIGHT)

VOR INDICATOR

COURSE AND RECIPROCOL INDEX POINTERS (TOP & BOTTOM)
A. ROTATING COMPASS CARD
B. OMNIBEARING SELECTOR (OBS) ROTATES (A)
C. COURSE DEVIATION INDICATOR
D. TO-FROM INDICATOR

DOTS = each 2 is degrees off-course: 1 degree @ 60nm out is 1 nm off-course
VISUAL AND RADIO NAVIGATION

NAVIGATING USING THE VOR

IDENTIFY THE STATION

1. TUNE NAVIGATION RECIEVER TO THE FREQUENCY

2. LISTEN. MORSE CODE GIVEN FOR EACH STATION VERIFY BY LOOKING AT SECTION TO INSURE THAT YOU ARE REALLY ON THE CORRECT FREQUENCY

3. TURN THE OBS TO CHANGE THE ROTATING COMPASS CARD TO EITHER IDENTIFY WHERE YOU ARE OR TO SET THE COURSE YOU WANT TO FLY.
VISUAL AND RADIO NAVIGATION

INTERPRETING VOR INDICATIONS

YOU FLY THE RADIALS (TO-FROM) OF THE COMPASS ROSE
ALL 4 AIRPLANES ABOVE WILL PRODUCE THE SAME RESULT
IT DOES NOT TELL YOU YOUR ORIENTATION – ONLY YOUR
POSITION RELATIVE TO THE VOR. THIS IS A DIFFICULT
CONCEPT FOR NEWCOMERS TO GRASP … BE PATIENT…
VISUAL AND RADIO NAVIGATION

Both pilots set 090
Both have the same vor indication

Both pilots set 270
Both have the same vor indication

Magnetic North

VOR

090°M radial
VISUAL AND RADIO NAVIGATION

To determine your present direction from a VOR station, tune in the station and turn the OBS knob until the CDI needle centers with a FROM indication.

To determine the course from your present position to a VOR station, tune in the station and turn the OBS knob until the CDI needle centers with a TO indication.
VISUAL AND RADIO NAVIGATION

![Diagram of visual and radio navigation](image)

- Desired Course
- 345° Radial
- Omni
VISUAL AND RADIO NAVIGATION

HOW THE CDI CHANGES WHEN YOU CHANGE OR GET OFF-COURSE

Over or “abeam” VOR

CDI is course line – you are right of course. “Zone of Ambiguity” +/- 10 degrees perpendicular

Zone of confusion

You are left of course

This CDI indicates you are on the selected course.

This CDI indicates you are 4 degrees right of your selected course.

2-degree “dot”

Created by Steve Reisser
Winds change your track.
VISUAL AND RADIO NAVIGATION

INTERCEPTING / CHANGING RADIAL

You set up an intercept angle by turning left to a heading of 045°. Once established on your intercept course, you turn the OBS to set the new inbound course, 090°, in the VOR indicator.

When the CDI begins to center, you turn right and track inbound to the station.

While tracking inbound on the 250° radial, you see cumulus clouds ahead and decide to approach the station on the 270° radial.
VISUAL AND RADIO NAVIGATION

VOR RADIALS CAN BE USED AS “CHECKPOINTS”
VISUAL AND RADIO NAVIGATION - Locate your position

YOU ARE HERE
VISUAL AND RADIO NAVIGATION
VOR INTERSECTIONS: 2 VOR RADIALS INTERSECT

SECTIONAL

LLEEnroute
VISUAL AND RADIO NAVIGATION
Low Enroute Charts Great for VOR Navigation
VISUAL AND RADIO NAVIGATION

CAUTION – REVERSE SENSING
AVOID ERRORS BY FLYING “TO” THE STATION
ELSE CDI WILL OPERATE IN OPPOSITION TO NORMAL MANNER.

If the VOR indicator is set to 090° in aircraft A and B, the CDI will deflect to the left with a FROM indication in both cockpits, even though the aircraft are headed in opposite directions.

If the pilot of aircraft A (heading 270°) follows normal procedures and turns toward the needle (left) to regain course, the aircraft will actually be flying away from the intended course.

Since the VOR indicator is set to generally match the heading of aircraft B (090°) a left turn (toward the needle) will result on the proper correction.
VISUAL AND RADIO NAVIGATION

TO AVOID CONFUSION – TO RECOGNIZE THE HOW THE CDI SHOULD APPEAR, YOU NEED TO VISUALIZE WHAT THE CDI WILL LOOK LIKE IN THE AIRPLANE.

THINK: HOW SHOULD IT LOOK?

** GUARENTEED ** YOU WILL SEE THESE ON YOUR PRIVATE WRITTEN EXAMINATION
A 360°F
B 180°T
C 270°T
D 270°T
E 130°F
F 180°F
G 180°F
H 270°F

Airplane

REVERSE SENSING = Light Blue
### VISUAL AND RADIO NAVIGATION

<table>
<thead>
<tr>
<th>On which radial are you located?</th>
<th>Which course takes you to the station?</th>
<th>How does the CDI deflect, if you follow Hdg. 060?</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 005</td>
<td>a) 005</td>
<td>a) to the left</td>
</tr>
<tr>
<td>b) 085</td>
<td>b) 085</td>
<td>b) to the right</td>
</tr>
<tr>
<td>c) 185</td>
<td>c) 185</td>
<td>c) remain constant</td>
</tr>
<tr>
<td>d) 275</td>
<td>d) 275</td>
<td></td>
</tr>
</tbody>
</table>

On which radial are you located?  c  185

Which course takes you to the station?  a  005

How does the CDI deflect, if you follow Hdg. 060?  a  to the left
### VISUAL AND RADIO NAVIGATION

<table>
<thead>
<tr>
<th>On which radial are you located?</th>
<th>Which course takes you to the station?</th>
<th>How does the CDI deflect, if you follow Hdg. 260?</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) 035</td>
<td>a) 035</td>
<td>a) to the left</td>
</tr>
<tr>
<td>b) 045</td>
<td>b) 045</td>
<td>b) to the right</td>
</tr>
<tr>
<td>c) 215</td>
<td>c) 215</td>
<td>c) remain constant</td>
</tr>
<tr>
<td>d) 225</td>
<td>d) 225</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>On which radial are you located?</th>
<th>Which course takes you to the station?</th>
<th>How does the CDI deflect, if you follow Hdg. 260?</th>
</tr>
</thead>
<tbody>
<tr>
<td>b) 045</td>
<td>d) 225</td>
<td>a) to the left</td>
</tr>
</tbody>
</table>
# VISUAL AND RADIO NAVIGATION

<table>
<thead>
<tr>
<th>On which radial are you located?</th>
<th>Which course takes you to the station?</th>
<th>How does the CDI deflect, if you follow Hdg. 140?</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) 060</td>
<td>(a) 060</td>
<td>(a) to the left</td>
</tr>
<tr>
<td>(b) 160</td>
<td>(b) 160</td>
<td>(b) to the right</td>
</tr>
<tr>
<td>(c) 240</td>
<td>(c) 240</td>
<td>(c) remain constant</td>
</tr>
<tr>
<td>(d) 340</td>
<td>(d) 340</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>On which radial are you located?</th>
<th>Which course takes you to the station?</th>
<th>How does the CDI deflect, if you follow Hdg. 140?</th>
</tr>
</thead>
<tbody>
<tr>
<td>(c) 240</td>
<td>(a) 060</td>
<td>(b) to the right</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
VISUAL AND RADIO NAVIGATION

IMPORTANT

Outbound (away from VOR) – Fly “FROM” outbound radial
Inbound (towards VOR) – Fly “TO” on reciprocal radial

WARNING: REVERSE SENSING IS CONFUSING
EVERYTHING INDICATES OPPOSITE IF YOU VIOlate THIS RULE

Cool reciprocal conversion rule of thumb
For courses 10-180 (+2 -2 to 1st and 2nd digit position)

<table>
<thead>
<tr>
<th>1</th>
<th>4</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>+2</td>
<td>-2</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

For courses 190-360 (-2 +2 to 1st and 2nd digits)

<table>
<thead>
<tr>
<th>3</th>
<th>2</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>-2</td>
<td>+2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

(this also works when your quickly trying to determine runway reciprocal headings)
VISUAL AND RADIO NAVIGATION

VOR Time & Distance Calculations

TURN 90 DEGREES (30+90=120). Record # of minutes to reach next 10 degree radial (040) Must set OBS to 40. Watch for “FROM” to center on intercept to identify when you have reached the 10 degree intersect. Note time.

TIME TO STATION
(Min flown between bearing change) \( \times 60 \)
(Degrees of bearing change)

DISTANCE TO STATION
TAS \( \times \text{TIME TO STATION} \)
Both VOR and ADF can use a principle related to an “isosceles” triangle. If 2 angles or the triangle are the same, then the lengths of the side are also the same.

Above flying TO 090 if I set the OBS to fly inbound on 080 (10 degrees different), turn the airplane to the right 10 degrees 100 (10 degrees different) time minutes until I intercept 080 TO, the time to that intercept (X) is the time to the destination!!

STRAIGHT CALCULATION

You can use angles less: Example flying 125KT, 5 degree change takes 2.5 mins. burning 15 gallons per hour.
Time to station is 60 x Mins (2.5) = 150 / 5 degrees = 30 minutes
Distance to station Speed x Mins = 312.5 / 5 degrees = 62.5 NM
Fuel to station GPH x (Mins/60) = 7.5 Gallons
26. (Refer to Figure 23 below.) If the time flown between aircraft positions 2 and 3 is 13 minutes, what is the estimated time to the station?

A. 7.8 minutes.
B. 13 minutes.
C. 26 minutes.

Answer (B) is correct. *(IFH Chap 7)*

**DISCUSSION:** The time/distance to station can be found by application of the isosceles triangle principle (i.e., if two angles of a triangle are equal, two of the sides are also equal), as follows:

1. With the aircraft established on a radial (here 90°) inbound, rotate the OBS 20° to the right, i.e., 110°.
2. Turn 20° to the left and note the time.
3. Maintain constant heading until the CDI centers, and note the elapsed time.
4. Time to station is the same as the time taken to complete the 20° change of bearing.

Thus, if the time flown between aircraft positions 2 and 3 is 13 min., the estimated time to the station is also 13 min.

Answer (A) is incorrect because the time between positions 2 and 3 and between position 3 and the station should be equal, i.e., 13 min. Answer (C) is incorrect because the time between positions 2 and 3 and between position 3 and the station should be equal, i.e., 13 min.

---

**Figure 23. – Isosceles Triangle.**
27. (Refer to Figure 22 below.) If the time flown between aircraft positions 2 and 3 is 8 minutes, what is the estimated time to the station?

A. 8 minutes.
B. 16 minutes.
C. 48 minutes.

Answer (A) is correct. *(IFH Chap 7)*

**DISCUSSION:** The time/distance to station can be found by application of the isosceles triangle principle (i.e., if two angles of a triangle are equal, two of the sides are also equal), as follows:

1. With the aircraft established on a radial (here 270°) inbound, rotate the OBS 5° to the left, i.e., 265°.
2. Turn 5° to the right and note the time.
3. Maintain constant heading until the CDI centers, and note the elapsed time.
4. Time to station is the same as the time taken to complete the 5° change of bearing.

Thus, if the time flown between aircraft positions 2 and 3 is 8 min., the estimated time to the station is also 8 min.

Answer (B) is incorrect because the time between positions 2 and 3 and between position 3 and the station should be equal, i.e., 8 min. Answer (C) is incorrect because the time between positions 2 and 3 and between position 3 and the station should be equal, i.e., 8 min.
10.2 VOR USE AND RECEIVER CHECKS

1. When checking the course sensitivity of a VOR receiver, the OBS should be rotated 10° to 12° to move the CDI from the center to the last dot.
   a. One-fifth deflection represents 2° off course, or 2 NM at 60 NM from the VOR station.

2. When using a VOT to make a VOR receiver check, the CDI should be centered and the OBS should indicate that the aircraft is on the 360° radial.
   a. To use a designated checkpoint on an airport surface, set the OBS on the designated radial.
      1) The CDI must center within ±4° of that radial with a FROM indication.
   b. When the CDI is centered during an airborne check, the OBS and the TO/FROM indicator should read within ±6° of the selected radial.
HORIZONTAL SITUATION INDICATOR

- NAV warning flag
- Lubber line
- Compass warning flag
- Course select pointer
- TO/FROM indicator
- Glide-slope deviation scale
- Heading select knob
- Compass card
- Course deviation scale
- Course select knob
- Dual glide-slope pointers
- Symbolic aircraft
- Heading select bug
- Course deviation bar (CDI)
**HORIZONTAL SITUATION INDICATOR (HSI)**

1. The horizontal situation indicator (HSI) is a combination of a heading indicator and a VOR/ILS indicator, as illustrated and described below.

   ![HSI Diagram]

   a. The azimuth card, which rotates so that the heading is shown under the index at the top of the instrument.
      1) The azimuth card may be part of a remote indicating compass (RIC).
      2) Or the azimuth card must be checked against the magnetic compass and reset with a heading set knob.

   b. The course indicating arrow, which is the VOR (OBS) indicator.

   c. The TO/FROM indicator for the VOR.

   d. Glide slope deviation pointer. It indicates above or below the glide slope, which is the longer center line.

   e. Glide slope warning flag, which comes out when reliable signals are not received by the glide slope deviation pointer.

   f. Heading set knob, which is used to coordinate the heading indicator (directional gyro, etc.) with the actual compass.
      1) If the azimuth card is part of an RIC, normally a heading bug (pointer) set knob moves a bug around the periphery of the azimuth card.

   g. Lubber line, which shows the current heading.

   h. Course deviation bar, which indicates the direction one would have to turn to intercept the desired radial if one were on the approximate heading of the OBS selection.

   i. The airplane symbol, which is fixed, showing the airplane relative to the selected course if seen from above the airplane looking down.

   j. The tail of the course-indicating arrow shows the reciprocal of the OBS heading.

   k. The course setting knob, which is used to adjust the OBS.
VISUAL AND RADIO NAVIGATION

AUTOMATIC DIRECTION FINDER (ADF)

GROUND EQUIPMENT: NONDIRECTIONAL RADIO BEACON (NDB)

Now being **DECOMMISSIONED**

Four types of ADF Indicators are in use. *In every case, the needle points to the navigation beacon.*

- Fixed Compass Card.
- Rotating Compass Card.
- Single-needle Radio Magnetic Indicator
- Dual-needle Radio Magnetic Indicator.

← coupled →
to DG
VISUAL AND RADIO NAVIGATION
VISUAL AND RADIO NAVIGATION

Magnetic Heading (MH), Relative Bearing (RB), and Magnetic Bearing (MB)

MH + RB = MB

"Mary Had Roast Beef. Mary Barfed"
VISUAL AND RADIO NAVIGATION

TIME: Minutes to Station = Time In Seconds / Degrees of Bearing Change

DISTANCE: NM to Station = TAS x Miles Flown / Degrees of Bearing Change

Flying 005 towards NDB. We decide to find time and distance to another NDB to our right. We want the NDB to be 90 degrees before starting a timer. We turn to “B” 025 degrees and wait until the pointer comes across 115 degrees (25+90) to start the clock.

When the ADF points to 115, we start the timer.

Continuing flight on 025 MH, we wait for the passage of another 10 degrees (115+10) or 125 and stop the timer.

Time= 220 secs /10 degrees = 22 mins.

Distance=110Kts*3.67 mins/10 degrees = 40 nm
Time To Station is: \[60 \times \text{Min. flown between bearing change}\]

\[\text{Degrees of bearing change}\]

Distance To Station is: \[\text{TAS} \times \text{Min. flown between bearing change}\]

\[\text{Degrees of bearing change}\]

**EXAMPLE:** The ADF indicates a 5° wingtip bearing change in 2.5 min. If the TAS is 125 kt., what is the time and distance to the station?

\[
\text{Time to station} = \frac{60 \times 2.5}{5} = \frac{150}{5} = 30 \text{ min.}
\]

\[
\text{Distance to station} = \frac{125 \times 2.5}{5} = \frac{312.5}{5} = 62.5 \text{ NM}
\]

To determine the fuel required, convert the time to station into hours and multiply by the fuel consumption as shown.

\[
\text{Fuel required} = \frac{\text{Rate of fuel consumption} \times \text{Min. to station}}{60}
\]

**EXAMPLE:** You are 20 min. from the station and your fuel burn is 15 GPH.

\[
\text{Fuel required} = \frac{15 \times 20}{60} = \frac{300}{60} = 5 \text{ gal.}
\]
### VISUAL AND RADIO NAVIGATION

Time and Distance to Station vs. Time to cross 10° for 110 kts. This is specifically for 110 kts. Different speeds will produce different results. Some pilots choose to make up their own tables for different cruise configurations.

<table>
<thead>
<tr>
<th>Time to cross 10° (Seconds)</th>
<th>Time to Station (minutes)</th>
<th>Distance to Station (nm)</th>
<th>Time to cross 10° (Seconds)</th>
<th>Time to Station (minutes)</th>
<th>Distance to Station (nm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>2</td>
<td>4</td>
<td>180</td>
<td>18</td>
<td>33</td>
</tr>
<tr>
<td>40</td>
<td>4</td>
<td>7</td>
<td>200</td>
<td>20</td>
<td>37</td>
</tr>
<tr>
<td>60</td>
<td>6</td>
<td>11</td>
<td>220</td>
<td>22</td>
<td>40</td>
</tr>
<tr>
<td>80</td>
<td>8</td>
<td>15</td>
<td>240</td>
<td>24</td>
<td>44</td>
</tr>
<tr>
<td>100</td>
<td>10</td>
<td>18</td>
<td>260</td>
<td>26</td>
<td>48</td>
</tr>
<tr>
<td>120</td>
<td>12</td>
<td>22</td>
<td>280</td>
<td>28</td>
<td>51</td>
</tr>
<tr>
<td>140</td>
<td>14</td>
<td>26</td>
<td>300</td>
<td>30</td>
<td>55</td>
</tr>
<tr>
<td>160</td>
<td>16</td>
<td>29</td>
<td>320</td>
<td>32</td>
<td>59</td>
</tr>
</tbody>
</table>
VISUAL AND RADIO NAVIGATION

INTERCEPTING AN ADF BEARING

Turn to desired bearing. (“A” 075) Note that station is 50 degrees to right.

DOUBLE that amount (50*2=100) and turn towards the needle (right) that amount (100). Course 075 changed to 175.

Maintain the course until the needle points to 075, then turn to head 075 and you will be on an intercept course to the station on 075.
10. (Refer to Figure 16 on page 246.) At the position indicated by instrument group 1, to intercept the 330° magnetic bearing to the NDB at a 30° angle, the aircraft should be turned

A. left to a heading of 270°.
B. right to a heading of 330°.
C. right to a heading of 360°.

Answer (C) is correct. (IFH Chap 7)

**DISCUSSION:** Draw a diagram as illustrated below.

![Diagram of ADF Navigation Problems]

Note you are west of the 330° MB because your RB is greater than 30° (on the 330° MB, you will have a 30° RB). Thus, you need to turn right. Since you wish a 30° intersection angle with the 330° MB, your heading should be 360°.

Answer (A) is incorrect because a MH of 270° will take you further from the 330° MB TO the station. Answer (B) is incorrect because a MH of 330° will parallel, not intercept, the 330° MB TO the station.
b. (Refer to Figure 18 below.) To intercept a magnetic bearing of 240° FROM at a 030° angle (while outbound), the airplane should be turned

A. left 065°.
B. left 125°.
C. right 270°.

Answer (B) is correct. *(IFH Chap 7)*

**DISCUSSION:** Draw a diagram as illustrated below. Read the illustration from right to left. You are on a 35° MH. Your RB is 310°. That identifies where the NDB is. Finally you want to draw the 240° MB outbound. To intercept the 240° MB at a 30° angle, you need a left turn from 35° to 270° which is 125°.

\[
\begin{align*}
\text{NDB} & \quad \text{MB}=345° \\
\text{MH}=35° \\
\text{MB}=240° \\
\text{RB}=310°
\end{align*}
\]

\[\text{MH} + \text{RB} = \text{MB} \]
\[035° + 310° = \text{MB (TO)} = 345°\]

Answer (A) is incorrect because a left 65° turn brings the airplane to a 330° MH, which will intercept the 240° MB FROM the station at a 90° angle, not 30° angle. Answer (C) is incorrect because a right 270° turn brings the airplane to a 305° MH, which will intercept the 240° MB FROM the station at a 65° angle, not a 30° angle.
13. (Refer to Figure 19 below.) If the airplane continues to fly on the magnetic heading as illustrated, what magnetic bearing FROM the station would be intercepted at a 35° angle?

A. 090°
B. 270°
C. 305°

Answer (C) is correct.  (*IFH Chap 7*)

DISCUSSION: Draw a diagram as illustrated below. Begin by determining your present MB.

\[
\begin{align*}
\text{MB (FROM)} &= 305° \\
\text{MH} &= 340° \\
\text{RB} &= 110° \\
340° + 110° + 180° &= \text{MB (FROM)} = 630° - 360° = 270°
\end{align*}
\]

You are now on the 270° MB (FROM). When you cross the 305° MB (FROM) of the NDB, you will have a 35° interception angle \((340° - 305° = 35°)\).

Answer (A) is incorrect because, on this heading, you will never cross the 090° MB (FROM). Answer (B) is incorrect because you are already on the 270° MB (FROM).
VISUAL AND RADIO NAVIGATION

ADF SHORELINE EFFECT - ERRORS

Area of Reliable Signal

Area of Shoreline Effect

Not reliable

30°
VISUAL AND RADIO NAVIGATION

NDB/ADF errors

**Electrical interference.** Radio waves are emitted by the aircraft alternator in the frequency band of the ADF. An alternator suppressor is fitted to contain those emissions but this component does not have a long life and it is wise to test the ADF for correct operation during pre-flight checks. The test is made by selecting a transmitter – which must be a reasonable distance away, say 30 nm – then watch the ADF needle during the engine run up. If the needle moves as rpm increase there is electrical interference and probably the alternator suppressor should be replaced. Magnetos may also interfere with the ADF.

**Thunderstorms** emit electrical energy in the NDB band and will deflect the ADF needle towards the storm.

**Twilight/night effect.** Radio waves arriving at a receiver come both directly from the transmitter – the ground wave – and indirectly as a wave reflected from the ionosphere – the sky wave. The sky wave is affected by the daily changes in the ionosphere, read the ionization layers section in the Aviation Meteorology Guide. Twilight effect is minimal on transmissions at frequencies below 350 kHz.

**Terrain and coastal effects.** In mountainous areas NDB signals may be reflected by the terrain which can cause the bearing indications to fluctuate. Some NDBs located in conditions where mountain effect is troublesome transmit at the higher frequency of 1655 kHz. Ground waves are refracted when passing across coast lines at low angles and this will affect the indicated bearing for an aircraft tracking to seaward and following the shore line.

**Attitude effects.** The indicated bearing will not be accurate whilst the aircraft is banked.
RADIO MAGNETIC INDICATOR (RMI)

1. The radio magnetic indicator (RMI) consists of a rotating compass card (heading indicator) and one or more navigation indicators that point to stations.

2. The magnetic heading of the airplane is always directly under the index at the top of the instrument.

3. The bearing pointer displays magnetic bearings to selected navigation stations.
   a. The tail of the indicator tells you which radial you are on.
   b. For example, the RMI above indicates a 015° magnetic heading, crossing the R-270 of VOR 1 (thin needle) and crossing the R-130 of VOR 2 (wide needle).
LORAN-C
Primarily based on marine navigation but works with aviation (considered “legacy” system). Now being DECOMMISSIONED.
DISTANCE MEASURING EQUIPMENT (DME and RNAV)

Accurate only DIRECTLY to or from station. Works on SLANT distance rather than ground distance. RNAV-Area Navigation: can create pseudo-VOR stations triangulating off existing stations. Allows direct flight path.
Inertial Navigation Systems (INS)
works independent of ground or satellite reference

extremely expensive