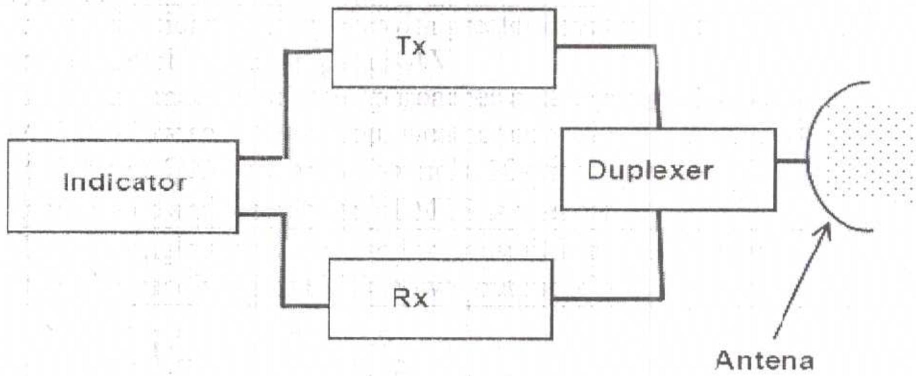
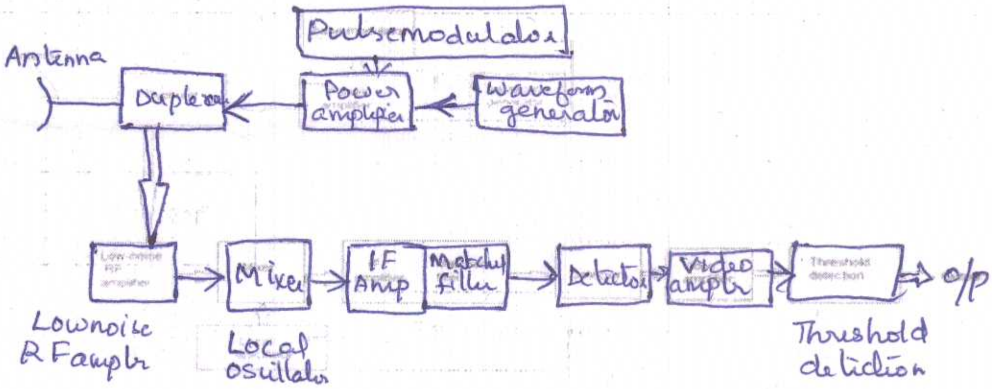
<u>Scheme of evaluation</u>

Course : **RADAR AND NAVIGATION**
Version : **2015**
Code : **6045**

Scoring indicators

<table>
<tr><th>Qn No.</th><th>Scoring indicator</th><th>Split Score</th><th>Sub total</th><th>Total</th></tr>
<tr><td>I 1</td><td>Pulse repetition frequency is the number of times a pulse activity occurs every second.</td><td></td><td>2</td><td rowspan="5"></td></tr>
<tr><td>I 2</td><td>• Improved guidance accuracy with greater coverage area.
• Provide flexible landing path NAV
• Offers guidance for missed approaches and departure NAV.
• MLS has low sensitivity from weather conditions and airport GNS traffic
• MLS offers 200 frequency channels, 10-times more than ILS.
• maintenance and installation of MLS is cheaper.</td><td>Any 2</td><td>2</td></tr>
<tr><td>I 3</td><td>It allows a single antenna to use for transmitting and receiving.
Protects the receiver from high power output of the transmitter.</td><td>1+1</td><td>2</td></tr>
<tr><td>I 4</td><td>$$f_d = \frac{2V_r}{\lambda} = \frac{2V_r f_o}{c}$$</td><td></td><td>2</td></tr>
<tr><td>I 5</td><td>LORAN,DECCA,OMEGA</td><td>Any 2</td><td>2</td></tr>
<tr><td>II 1</td><td>

OR


</td><td>Diag (3) + Exp (3)</td><td>6</td><td>30</td></tr>
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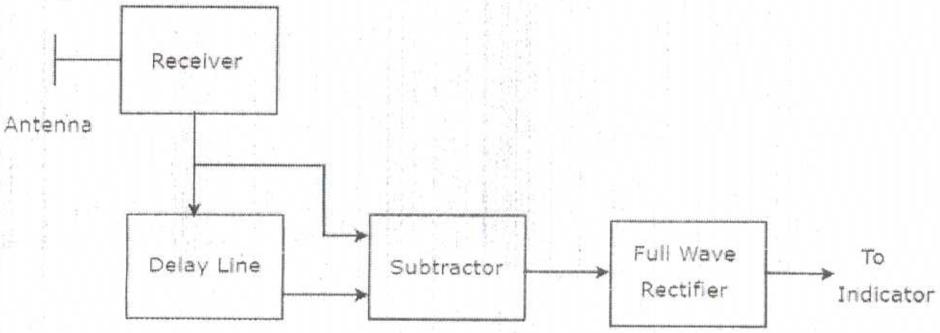
<tr>
<td>II 2</td>
<td>Delay line canceller is a filter, which eliminates the DC components of echo signals received from stationary targets. This means, it allows the AC components of echo signals received from non-stationary targets, i.e., moving targets. The combination of a delay line and a subtractor is known as Delay line canceller.

</td>
<td>3+3</td>
<td>6</td>
<td></td>
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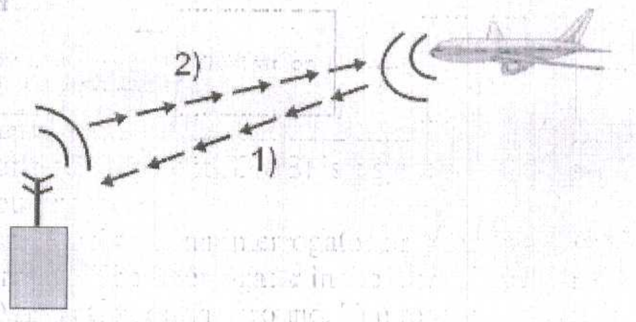
<tr>
<td>II 3</td>
<td>Distance Measuring Equipment (DME) is a system that is used in aviation for navigation purposes.
The DME system consists of an interrogator on board an aircraft and a DME station on the ground. The interrogator in the aircraft transmits interrogating pulses to the DME station on the ground. The received pulses trigger the DME station to reply. The reply is received by the aircrafts interrogating DME. The time difference between transmission and reception is used to calculate the distance from the aircraft to the DME station. Because the interrogation is repeated, the information can also be used to calculate the ground speed.


The DME in the aircraft measures the time difference between transmission (1) and reception (2) and uses this to calculate the distance
DME operates in the 960 - 1215 MHz band. The interrogator transmits on a center frequency of 1025 up to 1150 MHz. In this band are 126 frequencies with 1 MHz spacing defined. The DME station replies on a frequency that is either 63 MHz lower or 63 MHz higher.
The interrogator uses unique pairs of pulses. The same paring is used for the reply. This is to differentiate the answers from other answers send by the DME station. Modern DME stations can serve up to 200 aircrafts at the same time.</td>
<td>Diagram (3)
+
Explanation (3)</td>
<td>6</td>
<td></td>
</tr>
</table>

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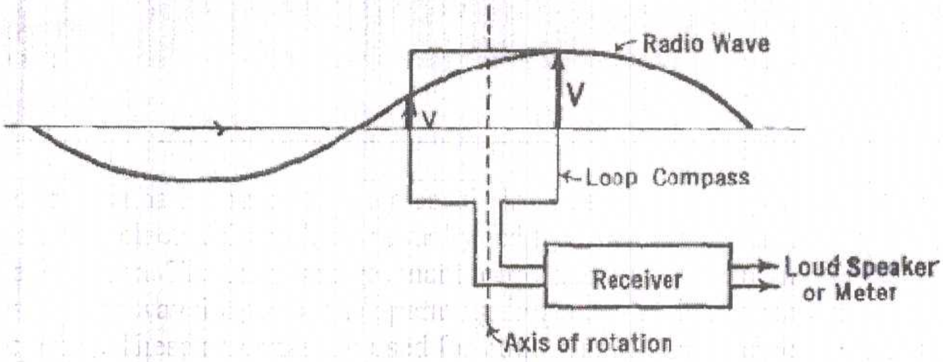
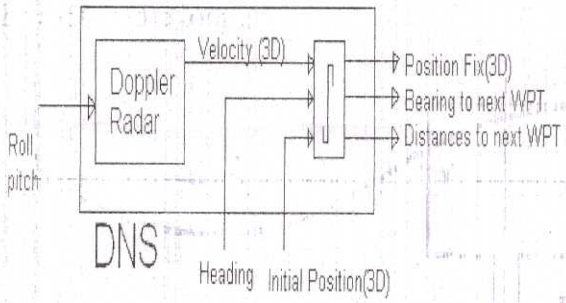
<tr><td>II 4</td><td>A loop antenna is a radio antenna consisting of a loop or coil of wire, tubing, or .another electrical conductor usually fed by a balanced source or feeding a balanced load. The large self-resonant loop antenna has a circumference close to one wavelength of the operating frequency and so is resonant at that frequency. These antennas are used for both transmission and reception. In contrast, small loop antennas less than 1% of a wavelength in size are very inefficient radiators, and so are only used for reception. The procedure is to rotate the loop antenna to find the direction where the signal vanishes – the "null" direction. Since the null occurs at two opposite directions along the axis of the loop,



</td><td>Diagram (3) + Explanation (3)</td><td>6</td><td></td></tr>
<tr><td>II 5.</td><td>DNS avionic system is a long range navigational aids and it stands for Doppler Navigation System.



DNS system provides Aircraft velocity (3D) and position fix (3D). This system is primarily used for military purposes requiring high speed low altitude flights. First, the aircraft velocity is obtained using the doppler radar, then the information is inputted to a NAV computer so that the position fix can be calculated. Also, similar to INS, this technology is a self contained system and therefore, does not depend on any outside source. In the Aircraft the system has following features.
• Tx and Rx is referred as DNS radar system.
• Operates at SHF frequency band (8.8 to 9.8 GHz and 13.25 to 13.40 GHz)
• Aircraft doppler radar transmits a beam to Ground.
• The beam is reflected and observed at the Aircrfat receiver with velocity information.
• Velocity is then integrated to obtain position.</td><td>Diag (3) + Exp (3)</td><td>6</td><td></td></tr>
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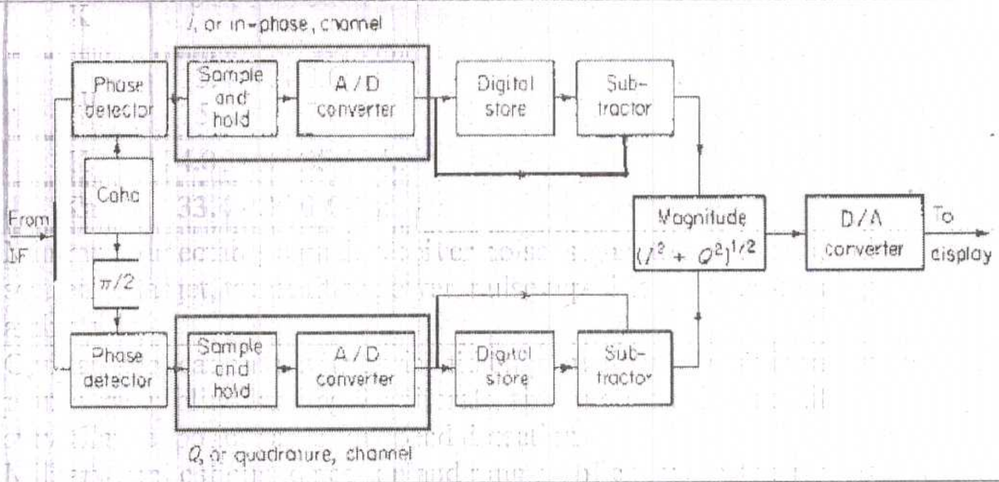
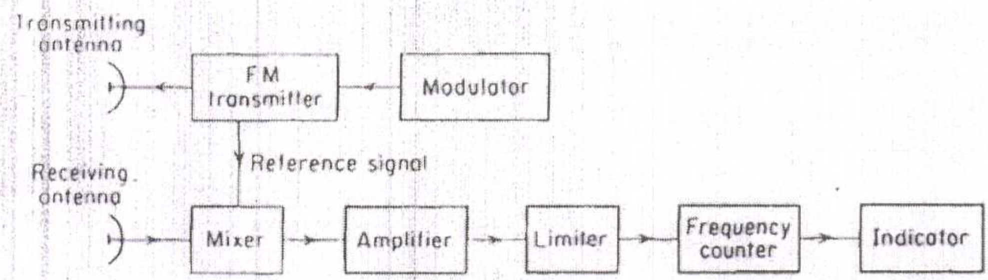
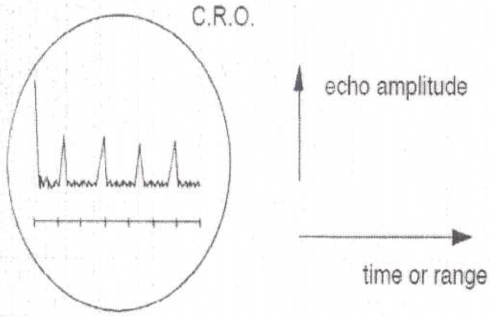
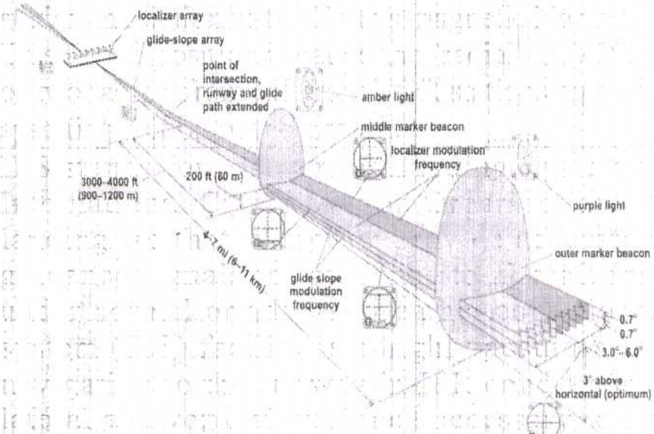
II 6.	• **STT Radar** (Single Target Tracking Radar) Continuously track a single target at a high data rate. Ex: Weapon control radar • **ADT Radar** (Automatic Detection and Tracking Radar) Lower data rate • Ex: Air Surveillance Radar • **TWS Radar** (Track While Scan Radar) Moderate data rate • Ex: Aircraft Landing Radar • **Angle Tracking Radar** When target is approaching the antenna is to be moved continuously to track the target • **Phased Array Tracking Radar** High data rate • Electronically steered phase array antenna • Used on time sharing basis • Ex: Air-defense weapon radar system	Any 4 with Exp (6)	6	
II 7.	The Glide Slope The Glide Slope is the signal that provides vertical guidance to the aircraft during the ILS approach. The standard glide-slope path is 3° downhill to the approach-end of the runway. Follow it faithfully and your altitude will be precisely correct when you reach the touchdown zone of the runway. Marker Beacons Marker beacons are used to alert the pilot that an action (e.g., altitude check) is needed. This information is presented to the pilot by audio and visual cues. The ILS may contain three marker beacons: inner, middle and outer. The inner marker is used only for Category II operations. The marker beacons are located at specified intervals along the ILS approach and are identified by discrete audio and visual characteristics (see the table below). All marker beacons operate on a frequency of 75 MHz.		6	
III (a)	$Power\ density = \frac{P_t}{4\pi R^2}$ $\text{Power density radiated by antenna} = \frac{P_t\ G}{4\pi R^2}$ $\text{Power at target} = \frac{P_t\ G\sigma}{4\pi R^2}$ $\text{Reradiated Power Density} = \frac{P_t\ G\sigma}{4\pi R^2} \times \frac{1}{4\pi R^2}$ $\text{Received signal power, } P_r = \frac{P_t\ G\sigma}{4\pi R^2} \times \frac{1}{4\pi R^2} \times A_e$ $S_{min} = P_r = \frac{P_t\ G\sigma}{4\pi R^2} \times \frac{1}{4\pi R^2} \times A_e$ $R^4_{max} = \frac{P_t G A_e \sigma}{(4\pi)^2 S_{min}}$ $R_{max} = \left(\frac{P_t G A_e \sigma}{(4\pi)^2 S_{min}}\right)^{\frac{1}{4}}$		8	15

<table>
<tr><td>III
(b)</td><td>
<table>
<tr><th>ITU Band</th><th>Frequency</th></tr>
<tr><td>VHF</td><td>138 - 144 MHz
216 - 225 MHz</td></tr>
<tr><td>UHF</td><td>420 - 450 MHz
890 - 942 MHz</td></tr>
<tr><td>L</td><td>1.215 - 1.400 GHz</td></tr>
<tr><td>S</td><td>2.3 - 2.5 GHz
2.7 - 3.7 GHz</td></tr>
<tr><td>C</td><td>5.250 - 5.925 GHz</td></tr>
<tr><td>X</td><td>8.500 - 10.680 GHz</td></tr>
<tr><td>Ku</td><td>13.4 - 14.0 GHz
15.7 - 17.7 GHz</td></tr>
<tr><td>K</td><td>24.05 - 24.25 GHz</td></tr>
<tr><td>Ka</td><td>33.4 - 36.0 GHz</td></tr>
</table>
</td><td></td><td>7</td><td></td></tr>
<tr><td>IV
(a)</td><td>Minimum detectable signal, receiver noise, signal to noise ratio, radar cross-section of target, transmitter power, pulse repetition frequency, range ambiguities</td><td>Any 4 and exp(8)</td><td>8</td><td rowspan="2">15</td></tr>
<tr><td>IV
(b)</td><td>Civilian application: navigational aid on ground and sea, radar altimeters for planes, radar blind landing for aircraft, airborne radar for satellite surveillance, police radar for speed detection
Military applications: detection and ranging of enemy target, aiming guns at aircraft and ships, bombing ships, aircraft even during night, directing guided missiles, searching for submarines, land masses</td><td>Any 7×1=7</td><td>7</td></tr>
<tr><td>V
(a)</td><td>
</td><td>Diagram (4) + explanation (4)</td><td>8</td><td rowspan="2">15</td></tr>
<tr><td>V
(b)</td><td>If there is relative motion between the source of a signal and the observer of the signal, along the line joining the two, then an apparent shift in frequency will result. This is the Doppler effect and is the basis of CW (Continuous Wave) radars.
$$f_d = \frac{2V_r}{\lambda} = \frac{2V_r f_o}{c}$$</td><td></td><td>7</td></tr>
</table>

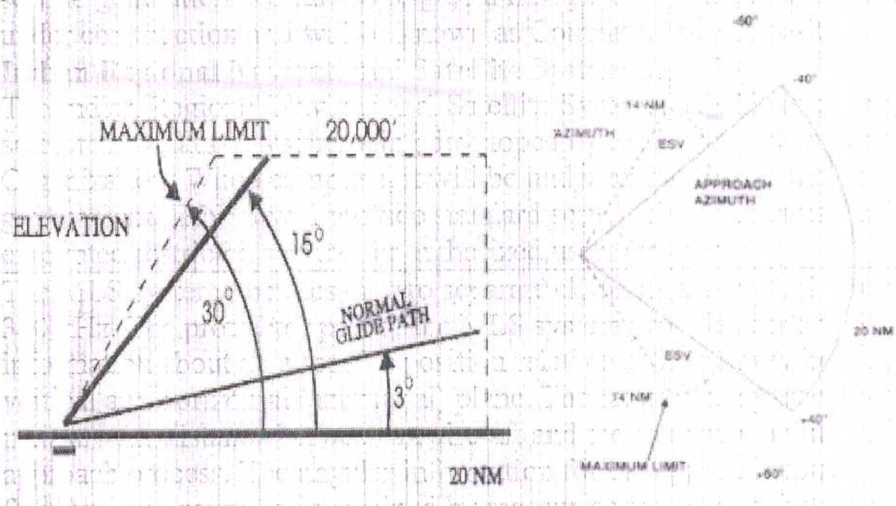
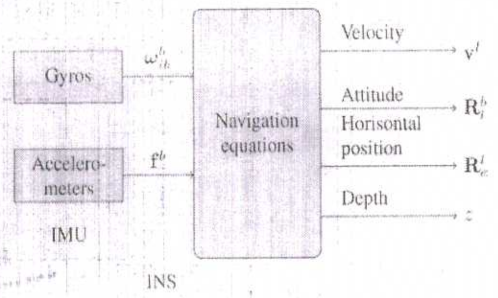
<table>
<tr><td>VI
(a)</td><td>
</td><td>Diag (4) + Exp (4)</td><td>8</td><td rowspan="2">15</td></tr>
<tr><td>VI
(b)</td><td>A-scopes were used on the earliest radar systems. The A-scope normally uses an electrostatic-deflection crt. The A-scope is a defection-modulated CRT display in which the vertical deflection is proportional to target echo amplitude and the horizontal coordinate is proportional to range.


A plan position indicator (PPI) is a type of radar display that represents the radar antenna in the center of the display, with the distance from it and height above ground drawn as concentric circles. As the radar antenna rotates, a radial trace on the PPI sweeps in unison with it about the center point. It is the most common type of radar display. The radar antenna sends pulses while rotating 360 degrees around the radar site at a fixed elevation angle. It can then change angle or repeat at the same angle according to the need. Return echoes from targets are received by the antenna and processed by the receiver and the most direct display of those data is the PPI.</td><td>4+3</td><td>7</td></tr>
<tr><td>VII
(a)</td><td>1. Navigation by Pilotage (or Visual Contact)
2. Celestial or Astronomical Navigation
3. Navigation by dead-reckoning
4. Radio Navigation
1 Navigation by Pilotage • In this method, the navigator fixes his position on a map by observing known visible landmarks. • Pilotage navigation requires good visibility • With aid of air-borne radar it is called as Electronic-Pilotage
2 CelestialNavigation • Also called as astronomical navigation is accomplished by measuring the angular position of celestial bodies. Almanacs giving the position of celestial bodies at various times measured in terms of GMT • The navigator measures the elevation of celestial body with a sextant and notes the precise time at which the measurement is made with a chronometer
3 Navigation by Dead-Reckoning • In this method, the position of craft at any instant of time is calculated from the previously determined position, the speed of its motion w.r.t. Earth along with the direction of its motion and the time elapsed
4 Radio Navigation • This method is based on Electromagnetic waves to find the position of the craft</td><td>4×2</td><td>8</td><td rowspan="2">15</td></tr>
<tr><td>VII
(b)</td><td>The ADF is a form of 'radio compass' that provides the pilot with the relative bearing of the beacon to which the equipment is tuned. On the ADF instrument in the cockpit, the needle points towards the selected beacon, enabling the pilot to fly the required procedure. The ADF works by using the electromagnetic properties of the signal produced by the beacon. Two antennae are required, which are known as the loop antenna and the sense antenna. In a typical ADF receiver, the signals received by the loop and sense antennae are combined to create the equivalent of a cardioid pattern. The ADF electronically and/or mechanically aligns the null with the transmitter station by rotating a goniometer. If the goniometer coil is not exactly</td><td></td><td>7</td></tr>
</table>

<table>
<tr><td></td><td>in the null, a loop voltage will be generated which is applied to a bi-phase motor which rotates the goniometer until it is in the null. Since the phase of the loop antenna signal either leads or lags that of the sense antenna depending upon which side of the null the rotor is positioned, the goniometer can be rotated in the correct direction to achieve the null. The output from the goniometer is then used to drive the needle on the ADF display in the cockpit.</td><td></td><td></td></tr>
<tr><td>VIII
(a)</td><td>LORAN (Long Range Navigation) is a radio-based navigational aid first used during World War II to locate ships and planes with greater accuracy than could be achieved with conventional techniques. LORAN determines location by comparing accurately-synchronized powerful radio pulses originating from different reference transmitter sites. Pulses from nearby transmitters arrive earlier than pulses from distant transmitters since radio signals travel at a constant speed. At least three different LORAN signals must be received to determine latitude and longitude. In practice, the distance to more than the minimum three LORAN signals increases accuracy. LORAN has evolved through three distinct phases, LORAN A, LORAN B, and the present version, LORAN C. The A and B versions were designed for navigational assistance over relatively short distances. LORAN C is reliable over distances of many hundreds of miles.</td><td>8</td><td rowspan="2">15</td></tr>
<tr><td>VIII
(b)</td><td>VOR, short for VHF Omni-directional Radio Range, is a type of radio navigation system for aircraft. VORs broadcast a VHF radio composite signal including the station's morse code identifier (and sometimes a voice identifier), and data that allows the airborne receiving equipment to derive the magnetic bearing from the station to the aircraft (direction from the VOR station in relation to the Earth's magnetic North at the time of installation). This line of position is called the "radial" in VOR parlance. The intersection of two radials from different VOR stations on a chart allows for a "fix" or specific position of the aircraft.</td><td>7</td></tr>
<tr><td>IX
(a)</td><td>ILS stands for Instrument Landing System and is a standard International Civil Aviation Organisation (ICAO) precision landing aid that is used to provide accurate azimuth and descent guidance signals for guidance to aircraft for landing on the runway under normal or adverse weather conditions. Instrument landing system (ILS) facility is a highly accurate and dependable means of navigating to the runway in IFR conditions. The ILS provides the lateral and vertical guidance necessary to fly a precision approach. When all components of the ILS system are available, including the approved approach procedure, the pilot may execute a precision approach. The ILS consists of: -


Localizer:- The primary component of the ILS is the</td><td>8</td><td>15</td></tr>
</table>

	localizer, which provides lateral guidance. The transmitter and antenna (Shown above) are on the centreline at the opposite end of the runway from the approach threshold. **Glide Path**:- The glide path component of ILS provides vertical guidance to the pilot during the approach. Glide path is located 750 to 1,250 feet (ft) down the runway from the threshold (shown above), offset 400 to 600 ft from the runway centre line. **Markers:-** **(i) Outer marker; (OM):** The outer marker (if installed) is located 3 1/2 to 6 NM from the threshold within 250 ft of the extended runway centreline to provide the pilot with the ability to make a positive position fix on the localizer. **(ii) MIDDLE MARKER (MM)**: The middle marker (if installed) is located approximately 0.5 to 0.8 NM from the threshold on the extended runway centerline. The middle marker crosses the glide slope at approximately 200 to 250 ft above the runway elevation. **DME** : Distance Measuring Equipment (DME) is normally collocated with glide path and provides slant distance to the aircraft with respect to touch down point. **The approach lighting system**:-Various runway lighting systems serve as integral parts of the ILS system to aid the pilot in landing. Any or all of the following lighting systems may be provided at a given facility: approach light system (ALS), sequenced flashing light (SFL), touchdown zone lights (TDZ) and centerline lights (CLL-required for Category II & III operations.) **RUNAWAY VISUAL RANGE (RVR):** In order to land, the pilot must be able to see appropriate visual aids not later than the arrival at the decision height (DH) or the missed approach point (MAP).			
IX (b)	There are two types of satellite navigation systems: global and regional. Global navigation satellite systems (GNSS) provide coverage all over the world. Regional satellite navigation systems provide coverage just to one area. **Global Navigation Satellite System (GNSS)** **Global Positioning System (GPS)** The NAVSTAR GPS system is composed of 24 satellites, and was created by the U.S. Department of Defense. **Global Satellite Navigation System (GLONASS)** GLONASS is also composed of 24 satellites but was developed in the Soviet Union and is operated by the Russian Aerospace Defense **Galileo (In development)** Galileo is a global navigation system currently being developed by the European Union and European Space Agency intended primarily for civilian use. Named after the Italian astronomer Galileo Galilei, The 30-satellite system is expected to be completed in 2019. **Compass (In development)** Compass is a global navigation system currently being developed in China. It is the second generation of its regional BeiDou Satellite Navigation System (BDS), also known as BeiDou-2. Its completion is expected in 2020 and will consist of 35 satellites. **Regional Satellite Navigation Systems** **Quasi-Zenith Satellite System (QZSS)** The Quasi-Zenith Satellite System (QZSS) is a proposed three-satellite	Any 7	7	

	regional time transfer system and Satellite Based Augmentation System for the Global Positioning System that would be receivable within Japan and Australia. QZSS is targeted at mobile applications to provide communications-based services . **BeiDou Navigation Satellite System (BDS)** The BeiDou Navigation Satellite System (BDS) consists of two separate satellite constellations. The first is a limited test system that has been operating since 2000 known as BeiDou-1. The BeiDou-1 consists of three satellites and offers limited coverage and applications. Its navigation services have been mainly for customers in China and neighboring regions. the second generation is a full-scale global navigation system that is currently under construction and will be known as Compass, or BeiDou-2. **Indian Regional Navigational Satellite System (IRNSS)** The Indian Regional Navigational Satellite System (IRNSS) is a regional satellite navigation system being developed by the Indian Space Research Organization. When complete, it will be under control of the Indian government. IRNSS will provide standard service for civilian use and an encrypted restricted service for authorized users (military)			
X (a)	The MLS system operates on two separate channels at a mutual interval of 300 kHz. The protractor part of the MLS system provides continually information about an aircraft's position relative to the runway both in the vertical and horizontal (azimuthal) plane. The rangefinder part enables to measure the distance between an aircraft and the reference points in the approach process. The angular information for the approach course, descent, flare and go-around is determined by measuring the interval between two passages of an oscillating plane lobe through an onboard MLS antenna. 	Fig (4) + Exp (4)	8	15
X. (b)	Navigational aid that uses a computer, motion sensors (accelerometer), rotation sensors (gyroscope) and sometime, magnetometers to continuously calculate orientation and velocity of a moving object. 	Fig (3) + Exp (4)	7	