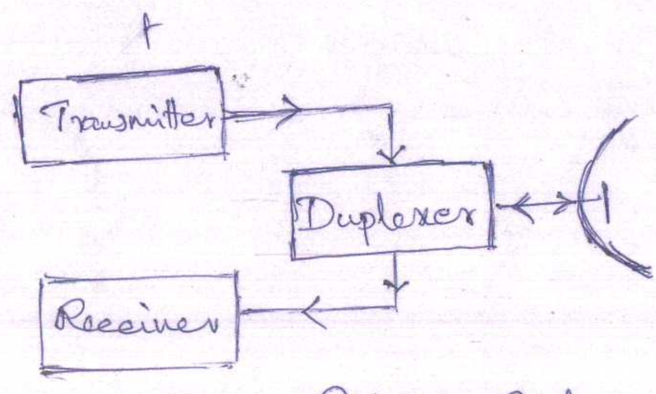
SCHEME OF VALUATION

(Scoring Indicators)

Course Code: 6045

vision 2015

urse Title RADAR AND NAVIGATION

.t)	Scoring Indicator	Split Up score	Total
I 1.	S band 1.5 – 3.9 GHz C band 3.9 – 8.0 GHz	2	
2.	Used for Surveillance Used for Navigation.	2	
3.	The apparent shift in frequency due to the relative movement of source and observer	2	10
4.	Directing the movements of a craft from one point to another along a desired path.	2	
5.	ILS presents the information about the position of the craft continuously with the help of instruments located both at the ground control and at the craft, and guides the craft to land safely even without the help of pilot.	2	
II 1.	 Elementary Pulsed Radar	3	

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	The duplexer ensures that either transmitter or receiver is connected to the antenna at any given time. The transmitter is connected to the antenna only during the generation of pulses. The echoes are received, amplified and demodulated, usually using superheterodyne principle. The pulses from the returning echoes are then fed to a display device,.	3	6
2.	For tracking of fast moving target like supersonic aircraft and for antiaircraft weapon system a continuous and fast tracking of the target is necessary. This is done by increasing the operating frequency to the millimeter wavebands thus reducing the antenna size allowing much faster scanning rates	2	
	The two types are 1) Continuous tracker 2) track-while scan radar		6
	In continuous tracker, the antenna beam orientation is controlled by a servomechanism activated by an error signal generated. ~~by~~	2	

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	In the track-while scan radar target co-ordinates are measured each time the antenna beam scans through the target and the target track is then reconstructed by joining the successive positions of the target displayed.	2	
3.	Any unwanted echo usually from stationary objects which makes the detection of desired targets difficult	2	
	Clutter is eliminated using MTI radars which utilizes ambiguous doppler measurement but with unambiguous range measurement. Here MTI systems compares a set of received echoes with those received during the previous sweep. Those echoes whose phase has remained constant are then canceled out (ie clutter echoes) but those due to moving targets do show a phase change and are not cancelled.	4	6
4.	A loop antenna consists of a rectangular loop with its plane vertical and can be rotated about the vertical axis. Voltages are induced in the vertical members but not in its horizontal members as the wave is vertically polarized (say), and		

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	they are out of phase. The loop is rotated until a null is obtained as output of the loop. A goniometer consists of two loop antennas mutually perpendicular and are stationary, and a rotor which can be rotated about the axis of symmetry. Here again the rotor is rotated till a null is detected as output. The voltage induced in the rotor is maximum when the flux is perpendicular to the plane of the rotor and zero when it is parallel to the plane	6	
5.	VOR operates in the VHF band. The range transmitter radiates two patterns, one of which is omnidirectional and carries the modulation of a reference 30Hz sinusoid, while the second pattern is a figure-of-eight rotating at 30 rps and the combination gives rise to a rotating cardioid. At the receiving end the rotating cardioid, after demodulation, gives a 30 Hz	6	

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	signal of variable phase, while the omnidirecti-onal signal gives a 30Hz signal of fixed reference phase. The phase difference at different radial position may be directly displayed as different phase angle.		
6.	GPS consists of 21 satellites, in six inclined orbital plane each inclined at 55° to the equatorial plane at a height of 20200 km above the earth and orbits with a period of 12 hours. All the satellites carry highly stable atomic clocks. The GPS receiver on the earth is provided with a high precision clock synchronized with satellite clock. The distance of the satellite from the receiver is calculated and the location of the receiver is found as the inter-section of three imaginary spheres produced by three satellites whose cordinates are found considering the centre of earth as origin, the z axis being the axis of earth's rotation, and x-y plane the equatorial plane.	6	

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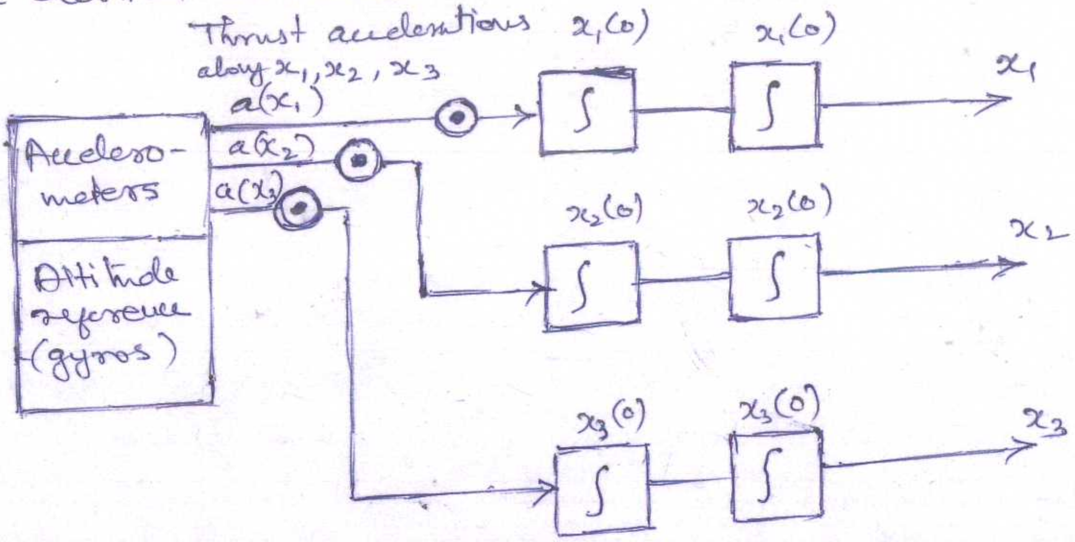
7.	Inertial Navigation System is a system of dead-reckoning navigation in which the instrument in the craft determine its acceleration by means of accelerometer and by successive integration obtain its velocity and displacement. A set of gyroscopes maintain the direction of these accelerations along the desired co-ordinates.	3	6
		3	

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III a.	If the transmitted power is P_t and the antenna is isotropic, then the power density at a distance r from the antenna is given by $$P.D = \frac{P_t}{4\pi r^2}$$ For a directive (ie practical) antenna $$P.D = \frac{P_t G}{4\pi r^2}$$ where G = max. directive gain of the antenna Now the power impinging on the target $$P = P.D \times \sigma$$ where σ = radar cross-section Since the target is not an antenna (almost always) the reflected radiation may be thought of as omnidirectional ie the Power density at the radar antenna is $P/4\pi r^2$ $$= \frac{P_t G \sigma}{(4\pi r^2)^2}$$ The received power then is $$P' = \frac{P_t G \sigma A_o}{(4\pi r^2)^2}$$ where A_o is the capture area of the radar antenna	9	

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	If the range ie 'r' is maximum the power received by the antenna will be minimum. Then $$r_{max} = \left[\frac{P_t G \sigma A_o}{(4\pi)^2 P'_{min}}\right]^{1/4}$$		
III b.	Radar cross section may be defined as the projected area of a perfectly conducting sphere which would reflect the same power as the actual target reflects, if it were located at the same spot as the target.	3	6
	If the target is small compared to a wavelength the cross sectional area for radar appears much smaller than its real cross section when the circumference (assuming a spherical target) is between 1 and 10 wavelengths the radar cross section oscillates. For shorter wavelengths the radar and true cross section are equal.	3	
IV	Receiver noise: It may originate within the receiver or may enter via the receiving antenna with the desired signal. A part is generated by the active devices and the other part is as thermal agitation noise		

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	It is directly proportional to the resistance R, the temp. T of the circuit and the receiver bandwidth. and is given by the mean square voltage $= 4kTBR$ where k = Boltzman Constant Signal to Noise ratio: Measured at the output of the IF amplifier Transmitter Power: The power given in radar range equation is the peak power. The average power is also important, which is the average transmitter power over the pulse repetition period, and is given by $P_{av} = \frac{P_t \tau}{T_p}$ where τ is the width of the rectangular pulse and T_p is the pulse repetition period. The ratio $\frac{P_{av}}{P_t} = \frac{\tau}{T_p}$ is called the duty cycle of the radar. The typical value is 0.01. Pulse repetition frequency: It is determined mainly by the maximum range. The maximum unambigous range is increased by decreasing the pulse repetition freq. The ambiguity in range can be minimized by varying the pulse repetition frequency. Here echoes from multiple time around targets is spread over a finite	15	

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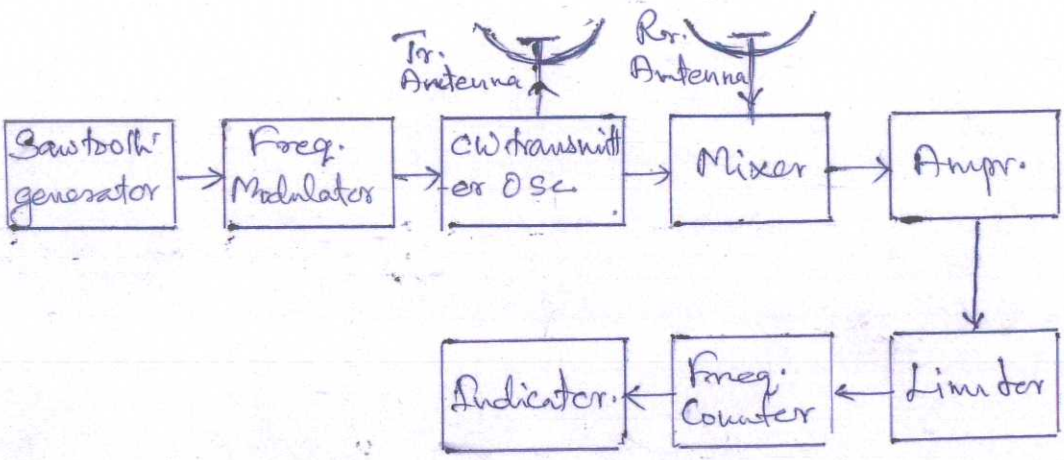
	range. Pulse duration: Duration determines the accuracy of range determination. The shorter the pulse more precise the measurement becomes. A shorter pulse however needs increased bandwidth requirement which in turn increases the noise acceptability hence decreasing the range. Also a short pulse will fail to excite the phosphorescent screen adequately which demands a higher echo signal power, which also reduces the range.		
V			
	A sawtooth waveform frequency modulates the high frequency carrier and is transmitted using the separate transmitting antenna. A portion of transmitted		

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	output is mixed with the received ~~mixer~~ doppler shifted signal and is fed to the amplifier. If the target is stationary with respect to the ~~tran~~ Radar, even then a frequency difference proportional to the distance of the target will exist between the transmitted and received signal because of the time varying nature of frequency produced by modulation. This difference frequency is measured and is given to the indicator whose output is calibrated in meters.	9	
	If the relative velocity of the radar and the target is not zero a beat frequency will superimpose on top of the average frequency difference obtained due to the time difference of transmission and reception. This beat frequency can be used to measure the velocity of the target		15
b.	Advantages: i Low transmitting power, simple circuitry, low power consumption, smaller size ii Unaffected by the presence of stationary objects. iii It can operate almost down to zero range because it is ON at all times.	6	

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iv	Capable of measuring a large range of target speeds quickly and accurately.		
v	With some additional circuitry they can even measure the direction of the target		
	Limitations :		
i	Maximum range is limited because of the limitation in transmission of maximum power		
ii	Easily confused by the presence of large no. of targets.		
iii	Incapable of indicating the range of the target		
VI a.			

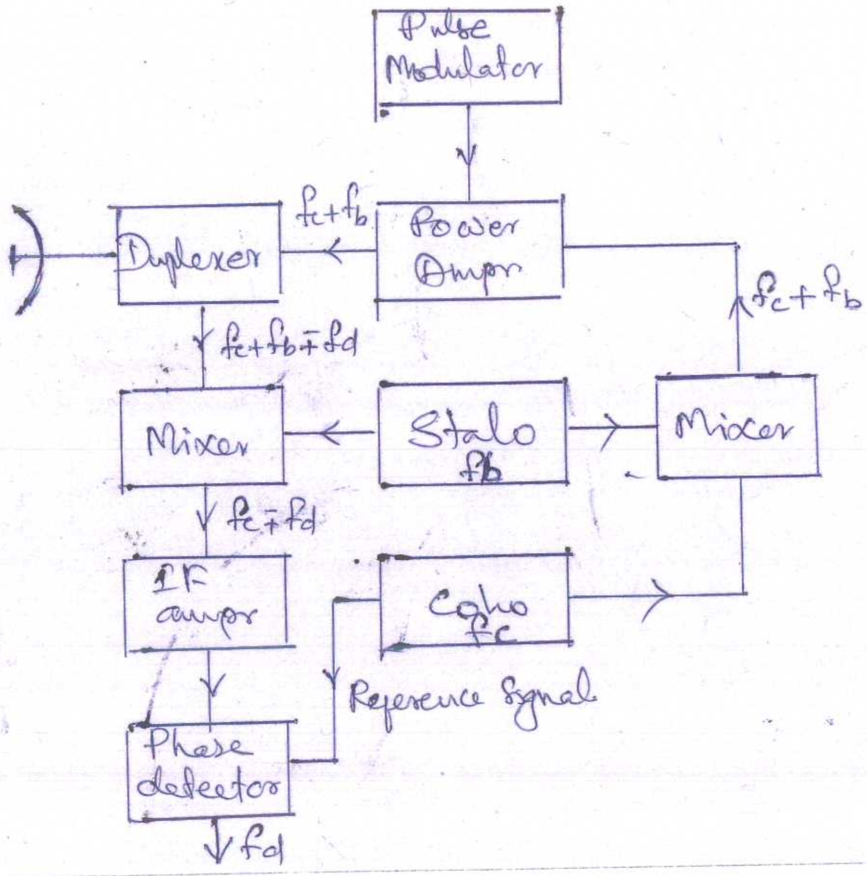

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	Figure shows the block diagram of MTI radar with power ampr. as the transmitter. Stalo provides the transmitted frequency in conjunction with Coho to produce $f_c + f_b$. It also serves as a local oscillator for the receiver section to generate an intermediate frequency signal at fc which in turn is detected by a phase detector with the Coho signal serving as a reference signal. The o/p of the phase detector is proportional to the doppler shift fd.	9	
b.	There are three ways by which the output of Radar are displayed. A scope: Similar to an ordinary oscilloscope display. A sweep waveform is applied to the horizontal deflection plates which is synchronized with the transmitted pulses so that the width of the CRT screen corresponds to the time interval b/w successive pulses. The demodulated receiver output is applied to the vertical deflection plates which produce vertical 'blips' in the screen. Displacement from the left hand side of the CRT thus represents the range of the targets, and the height of the blip'	6	

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	corresponds to the strength of the echo pulse. Plan Position Indicator: PPI display shows a map of the target area. The CRT is now intensity modulated so that the signal from the receiver after demodulation is applied to the grid of the CRT. The scanning waveform is applied to a pair of coils on opposite sides of the neck of the tube, so that magnetic deflection is used. The coils are rotated mechanically at the same angular velocity as the antenna. The brightness at any point on the screen indicates the presence of the object there, with its position corresponding to its actual physical position and its range being measured radially out from the centre. Automatic target detection: Here the received data will be processed before being displayed on the radar screen, and human intervention may not be required.		

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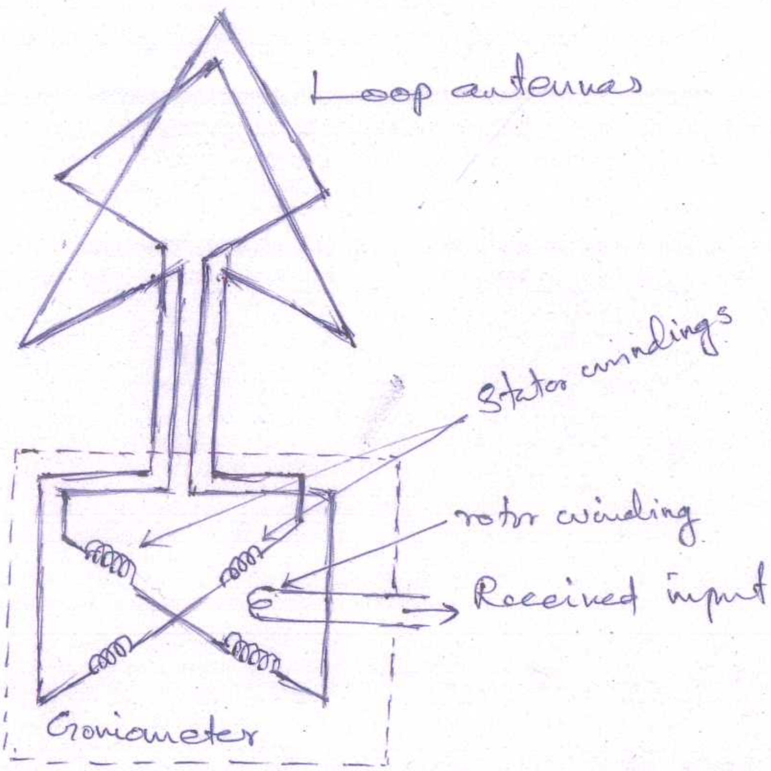
VII a.		4	
	Consists of two mutually perpendicular windings called stators and a winding at the center of these called the rotor, which can be rotated about the axis of symmetry. The voltage induced in the rotor, is fed to the receiver, which is equivalent to the voltage in a rotating loop antenna.	5	9
	The electromagnetic wave which is vertically polarized		

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	makes an angle θ with the plane of ~~the~~ any one of the loop. The currents flowing in the two loops are then proportional to $\cos\theta$ and $\cos(90-\theta)$ (being perpendicular to each other) and hence the flux produced in these coils are also proportional to $\cos\theta$ and $\sin\theta$. The voltage induced in the rotor is maximum when the flux is perpendicular to the plane of the rotor and zero when it is parallel to the plane of the rotor. The bearing can be found by turning the rotor to a null.		
b.	Navigation by Pilotage: Navigator fixes his position on a map by observing known visible land-marks such as rivers, hills etc.	2	
	Celestial Navigation: Accomplished by measuring the angular position of celestial bodies. Elevation of the celestial body is measured with a sextant and the precise time of measurement is found with a chronometer. These two measurements are enough to fix the position of the craft on a circle on the face of the globe. Two such observation will fix the craft as the intersection of two such circles.	2	6

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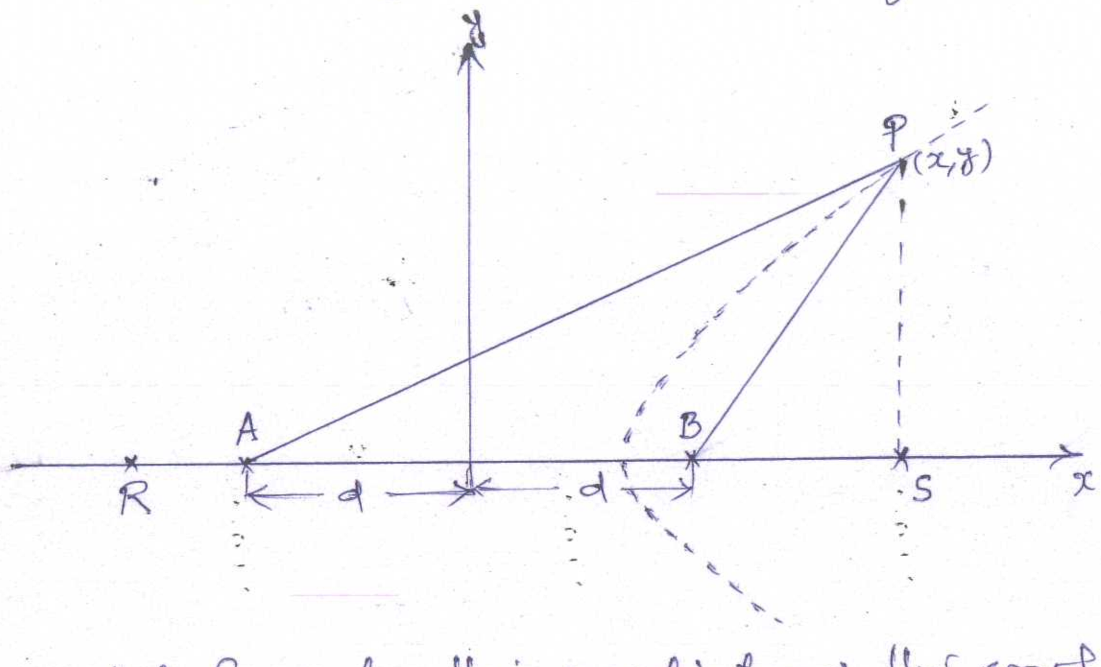
VIII	Navigation by Dead-reckoning: The position of the craft at any instant of time is calculated from the previously determined position, the speed of its motion with respect to earth along with the direction of motion and the time elapsed.	2	
	It is based on the measurement of the difference in the time of arrival of electromagnetic waves from two transmitters to the receiver in the craft. The locus of points which have a constant value of such delay is a hyperbola on a plane surface.	3	



Let P(x,y) be the coordinates of the craft

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	at an instant, from when is measured the delay in ~~transmission~~ reception of transmissions ~~from~~ between A and B. For a constant value of time delay we have $\frac{AP}{c} - \frac{BP}{c} = $ a constant, when $c = 3\times10^{8}$ m/sec Also $AP = \sqrt{(x+d)^2 - y^2}$ and $BP = \sqrt{(x-d)^2+y^2}$ On simplification $AP - BP \Rightarrow \frac{x^2}{a^2} - \frac{y^2}{b^2} = 1$ This is the equation of a hyperbola with foci at A and B. All the possible values of the delay gives a family of confocal hyperbolae. The determination of the delay locates the craft on one of these hyperbolae. ~~If~~ If there is a third synchronized station C, the determination of the delays between the reception of signals from A and B and also between those from B and C would locate the craft on two hyperbolae and their intersection gives the fix. Loran (Long range navigational aid) is a pulse system where the ground station transmits a train of pulses with fixed time relation between	5	

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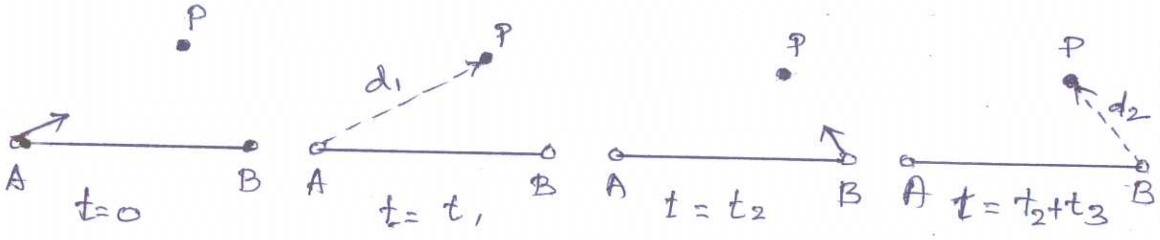
them and at the receiver, these pulses are identified and the delay between them is measured on a CRT.



The sequence of transmissions and receptions is shown above. At t=0 station A transmits $t = t_1 = d_1/c$ pulse reaches the craft. $t = t_2$ station B transmits. $t = t_2 + t_3$ the pulse reaches the craft. B starts to transmit after the pulse from A reaches B. The line AB is called the base line and is equal to 400 to 700 km — 7

Pulse repetition frequencies are in the region 20, 25, and 33⅓ Hz. The absolute delay (delay in transmission b/w A&B) must be greater than t_2 and usually is made more than half the repetition period. At the receiver the pulses are displayed on an oscilloscope which has a special type of time base in which the time period (of the pulse) is split into two parts, one half being displayed below the other

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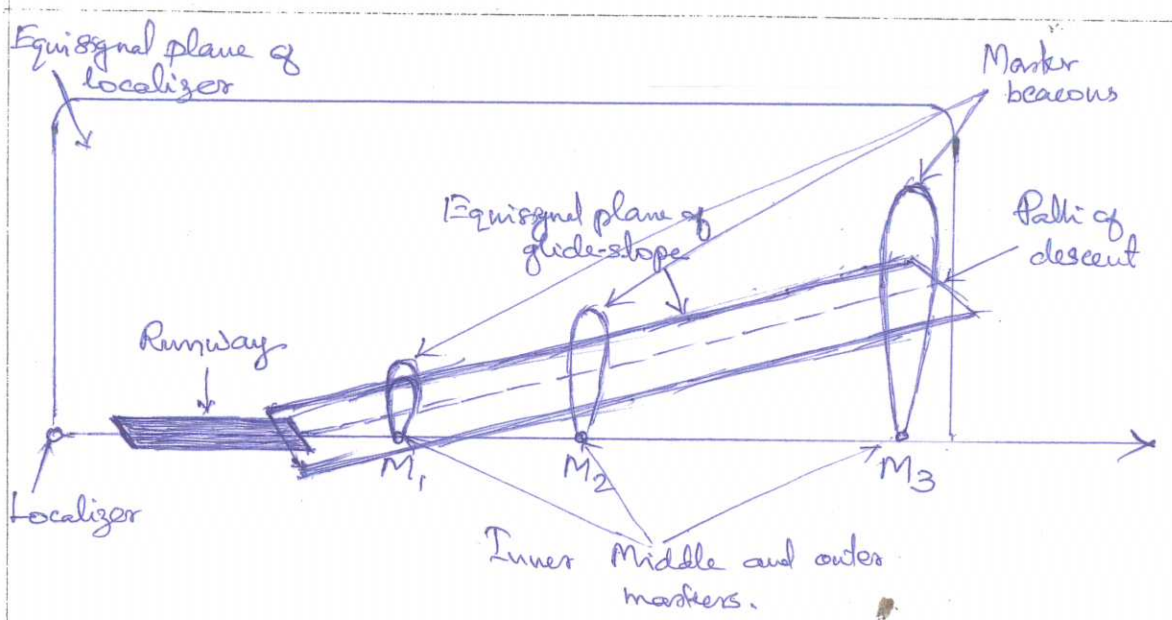
IX	(diagram below)	6	



The ILS consists of localizers, glide slope and marker beacons. The antenna system of the localizer defines a vertical equisignal plane which passes over the centre line of the runway. The glide slope is also an equisignal plane inclined to the horizontal plane. The intersection of the two planes provides the approach path. The marker beacons also provide indication in the aircraft about its position

Localizer: The antenna array ~~consisting of~~ which produce seven or eight Alford loops are placed on a line at right angles to the extended centre line of the runway and about 300m from the end of the runway These loops make up three arrays two of the three loops each on either

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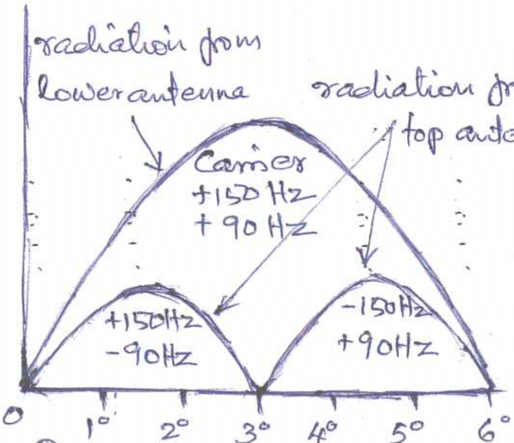
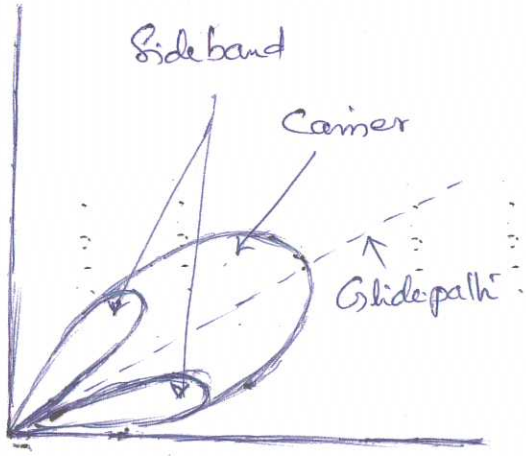
	side and the remaining one in the centre. The former are called side band loops and the latter the carrier antenna. The carrier modulated to the same depth by sinusoids of 90Hz and 150Hz is fed to the central antenna. To the other two arrays only the sidebands of 90Hz and 150Hz modulation are supplied. Along the central line, since the fields cancel (as the two antennas radiate in antiphase) there is a null, and on either side of it, the fields will not cancel, which can be detected by the craft.	3	
X.	Glide Slope System: The principle of operation is very similar to that of the localizer. Employs two antennas which produces radiation pattern as shown.		
	 In cartessian co-ordinates  In polar co-ordinates	3	

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	If the aircraft flies along the null it receives the signal of the lower antenna only and the two modulations are equal giving an equisignal course. Marker beacons: Operate at 75MHz and fanshaped beam of ±40° wide along the approach path and ±80° perpendicular to it. M_3 is about 7km from the touch down point on the runway. Modulation is by 400Hz. M_2 is about 1Km from the touchdown point and modulation is at 1300Hz. M_1 is placed when the glide path is about 30m above the ground. It is modulated at 3000Hz. In the aircraft a single receiver tuned to 75MHz is employed. The o/p is available as an audio signal and also actuates three lamps, one for each marker beacon	3	
X a.	ILS provides a single approach path along the ~~run~~ way. extended centre line of the runway. It is site-sensitive and subject to distortion and bending of the approach path due to site irregularities, because they operates in the VHF/UHF band where the beam shape is affected by the surrounding terrain. The no. of channels it can provide is limited to 40 and		

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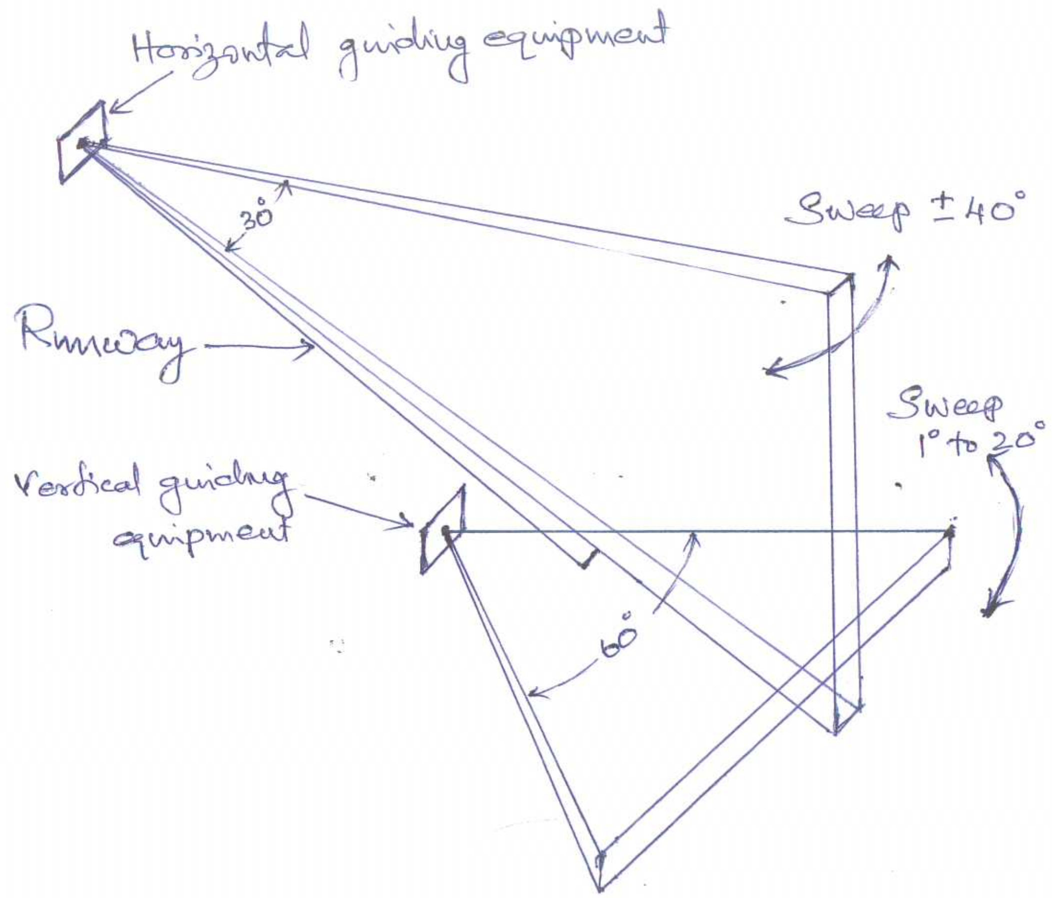
	is prone to interference from broadcasting stations. MLS can accommodate 200 channels. Because of the small wavelengths the antennas are small and can be designed to be relatively free from the effect of the surrounding area. They cover large area and permits approach by curved paths.	5	
b.			

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#. The azimuth beam equipment which is located at the far end of the runway produces a beam narrow in the horizontal plane and wide in the vertical plane which is swept rapidly about a vertical axis from side to side. The elevation beam equipment located at the end of the runway near the touchdown point produces a beam narrow in the vertical plane and wide in the horizontal plane scans about horizontal axis. A precision DME is located near the horizontal guiding equipment which gives the distance of the craft from the touch-down point. The aircraft picks up the signal of the horizontal guiding beam and depending upon the position of the craft w.r.to the runway the no. of times of pickup and the interval b/w the pick-up will vary. The angular position of the aircraft θ is given by $\theta = (t-T)\,\omega/2$ where t = interval b/w the two pick-up T = the scanning period ω = the angular velocity of the scan	10	

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#. At $+40^\circ$ $t = 2T$ and at -40°, $t = 0$ at $t = T$ along the central line. A microprocessor incorporated in the receiver computes the angle θ and will be displayed digitally. The glide-slope equipment employs the same scanning technique, with beam being swept b/w $1^\circ - 20^\circ$ The time duration of the horizontal scan is 4000μs where as that of vertical scan is 3350μs.		