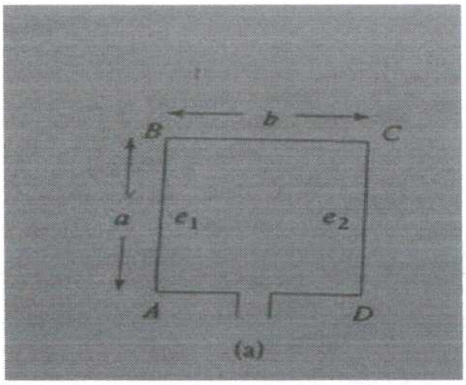
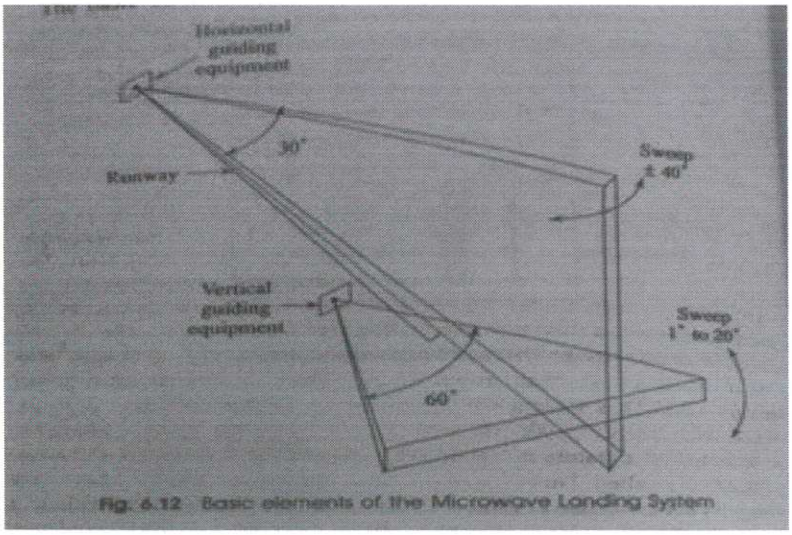
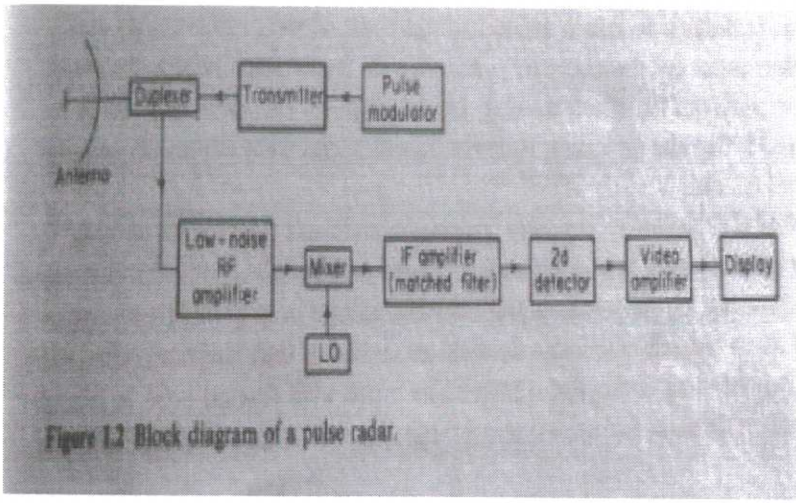
SCHEME OF VALUATION

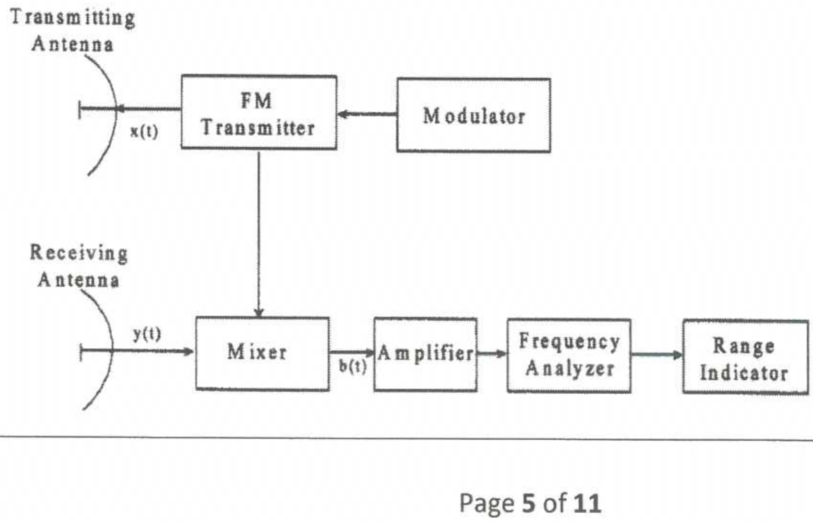
(Scoring indicators)

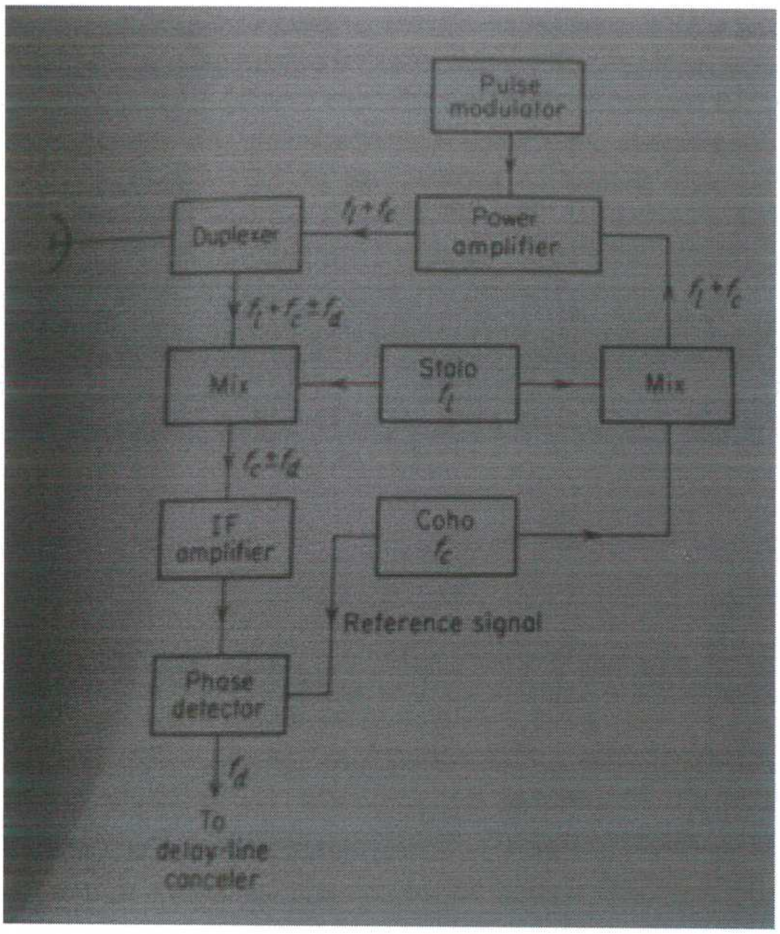
	Revision:2015 Course Code: 6045 **Course Title: RADAR AND NAVIGATION**			
Qst. No.	**Scoring Indicator**	**Split up score**	**Sub Total**	**Total**
I)	**PART A** 1). Radar is an electromagnetic system for the detection and location of reflecting objects such as aircraft, ships, spacecraft, vehicles, people, and the natural environment. It operates by radiating energy into space and detecting the echo signal reflected from an object or target.	2	2	2
	2). For better sensitivity and stability FM-CW super heterodyne receiver is used	2	2	2
	3).Loran-A operates in the higher MF band around 2MHz.	2	2	2
	4). GNSS-Global Navigation Satellite System is the standard generic term for satellite navigation systems that provide autonomous geo-spatial positioning with global coverage. GNSS is a term used worldwide the advantage to having access to multiple satellites in accuracy, redundancy and availability at all times.	2	2	2
	5).DGPS helps to know perfect location on the earth. Provide accurate data within a minute	2	2	2
II)	**PART B** 1). Applications of Radar • Air Traffic control • Aircraft Navigation • Ship safety • Space • Remote sensing • Law enforcement • Military	6	6	6

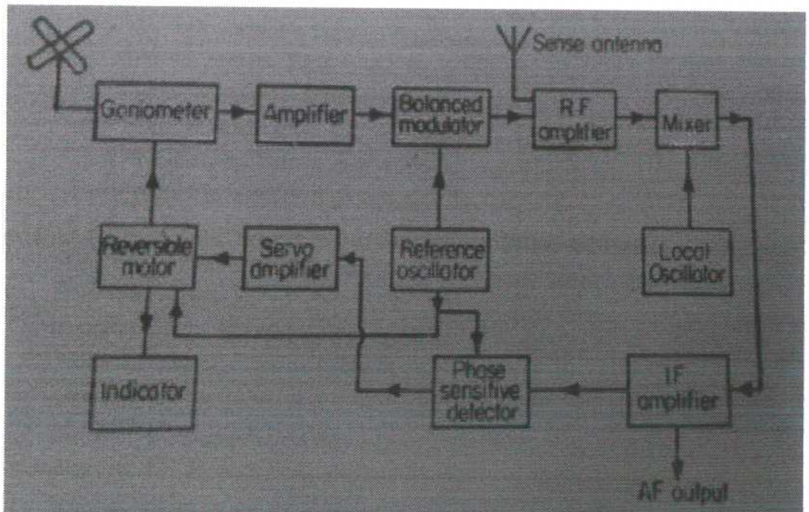
	2). The radar cross section of a target is the (fictional) area intercepting that amount of power which, when scattered equally in all directions, produces an echo at the radar equal to that from the target; or in other terms, Radar cross section= (power reflected toward source/unit solid angle)/ (incident power density/4π) $\sigma = \lim_{R->\infty} 4\pi R^2 \frac{\lvert E_s \rvert^2}{\lvert E_i \rvert^2}$	6	6	6
	3). If either the source of oscillation or the observer of the oscillation is in motion,an apparent shift in frequency will result. Doppler frequency shift is f_d=2Vr/λ where Vr- relative velocity λ- wavelength	6	6	6
	4). The Doppler frequency shift produced by moving a target may also be used in a pulse radar to determine the relative velocity of a target or to separate desired signals from moving targets and undesired signals from stationary objects(clutter). Though the Doppler frequency shift is sometimes used to measure relative velocity of a target using a pulse radar, its most interesting and widespread use has been in identifying small moving targets in the presence of large clutter. Such pulse radars which use the Doppler frequency shift to distinguish between moving targets are called MTI(Moving Target Indicators) and Pulse Doppler Radars. The physical principle of both these radars are the same but they differ in their mode of operation. The MTI radar operates on low PRF thus causing ambiguous Doppler measurements, but unambiguous range measurements. On the other hand the pulse Doppler radar operates on high PRF thus thus causing unambiguous range measurements.	6	6	6
	5). Consider a rectangular loop antenna of length 'a' and width 'b', with its plane vertical. Let there be a vertically polarized electromagnetic wave incident on it, coming from a direction making an angle θ with the plane of the loop. Voltages are induced in the vertical members of the loop. The output voltage is proportional to the area of the loop. Also the obtained voltage output of the loop is from the electric field of the incoming wave. The electric field is dependent on the direction of the incoming wave. This directional property can be used for direction finding.	Exp-4		

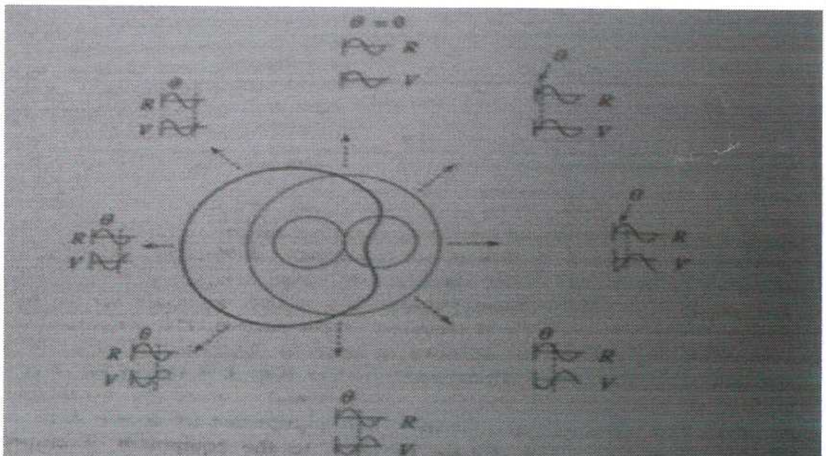
		Dia-2	6	6
	6). The omega system is a hyperbolic system of navigation which uses continuous waves of very low frequencies in the 10 KHz range. The advantage of using very low frequencies is that the coverage is increased. Eight stations distributed over the whole world give global coverage. Each station transmits a signal precisely controlled in time and frequency. To determine the line of position, each omega station can be paired with any other omega station. There are no masters and slaves. All the station constitutes one chain.	6	6	6
	7). The microwave landing system operates in the range of 5031 to 5090MHz. It was developed to overcome the disadvantages of ILS, particularly in busy airports. In ILS the number of channels is limited to 40. The MLS can accommodate 200 channels. The basic elements of MLS are shown in fig.  Fig. 6.12 Basic elements of the Microwave Landing System	Exp-3 Dia-3	6	6

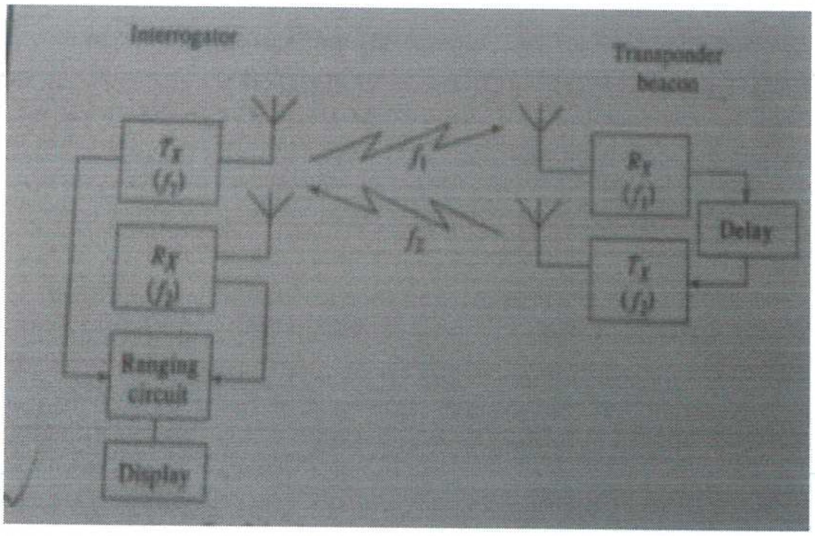
III)	**PART C**			
(a)	**Block diagram of Radar.**  Figure 1.2 Block diagram of a pulse radar.	Fig-5	10	10
	Transmitter maybe an oscillator, such as magnetron, that is pulsed by the modulator. A single antenna is generally used for both transmission and reception. The duplexer protects the receiver from high power of transmitter and channelize the returned echo signal to receiver. The receiver is usually of the Superheterodyne receiver type. The first stage might be a low noise RF amplifier, such as a parametric amplifier or a low noise transistor.	Exp-5		
(b)	The ability of a radar receiver to detect a weak echo signal is limited by the noise energy that occupies the same portion of the frequency spectrum as does the signal energy. The weakest signal the receiver can detect is called the minimum detectable signal	5	5	5

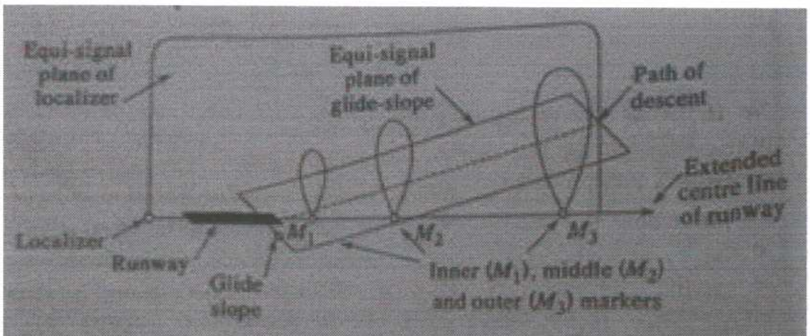
IV) (a)	Power density from isotropic antenna $=Pt/(4\pi R^{2})$ Power density from directive antenna $=(PtG)/(4\pi R^{2})$ Power density of echo signal at radar $=[(PtG)/(4\pi R^{2})]*[\sigma//(4\pi R^{2})]$ Power received by the radar is $Pr =[(PtG)/(4\pi R^{2})]*[\sigma//(4\pi R^{2})] *Ae$ $=(PtGAe\sigma)/((4\pi)^{2}R^{4})$ The maximum radar range Rmax is the distance beyond which the target cannot be detected. It occurs when the received echo signal power Pr just equals the minimum detectable signal Smin Hence $Rmax= =[(PtGAe\sigma)/((4\pi)^{2}Smin)]^{1/4}$	8	8	8
(b)	HF- 3-30MHz -OTH surveillance VHF 30-300MHz -Very long range surveillance UHF 300-1000MHz -Very long range surveillance L 1-2GHz -Long range surveillance S 2-4GHz -Moderate range surveillance C 4-8GHz - Long range tracking X 8-12GHz -Short range tracking Ku 12-18GHz - High resolution mapping K 18-27GHz -Little use(water vapor) Ka 27-40GHz -Very high resolution mapping Millimeter-40-300GHz -Experimental	7	7	7
V) (a)	In order to solve the inability of simple CW radar to measure range , we are using FM-CW radar. Some sort of timing mark must be applied to a CW carrier if range is to be measured. The timing mark is the changing frequency in FM-CW radar. The block diagram of FM-CW radar is shown in fig. 	Exp-4 Dia-4	8	8

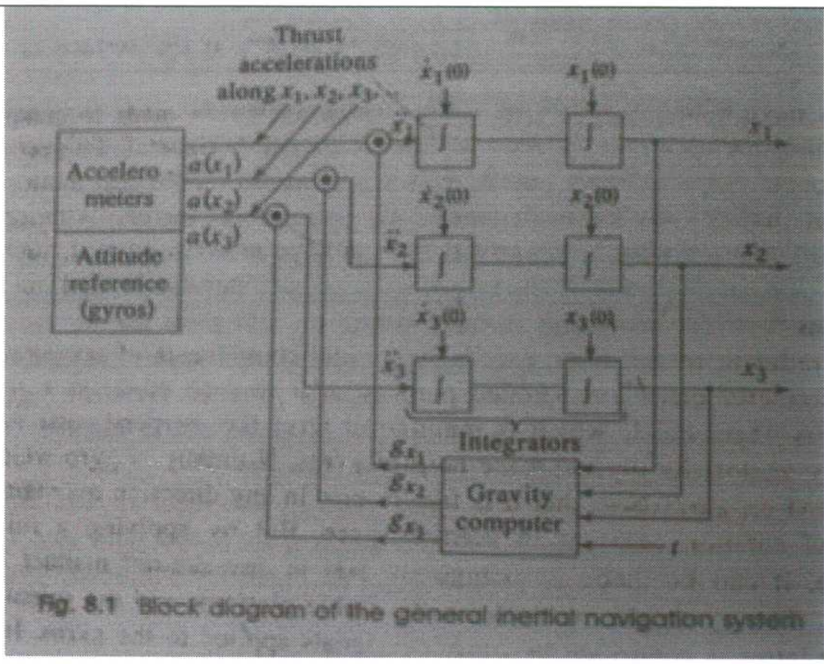
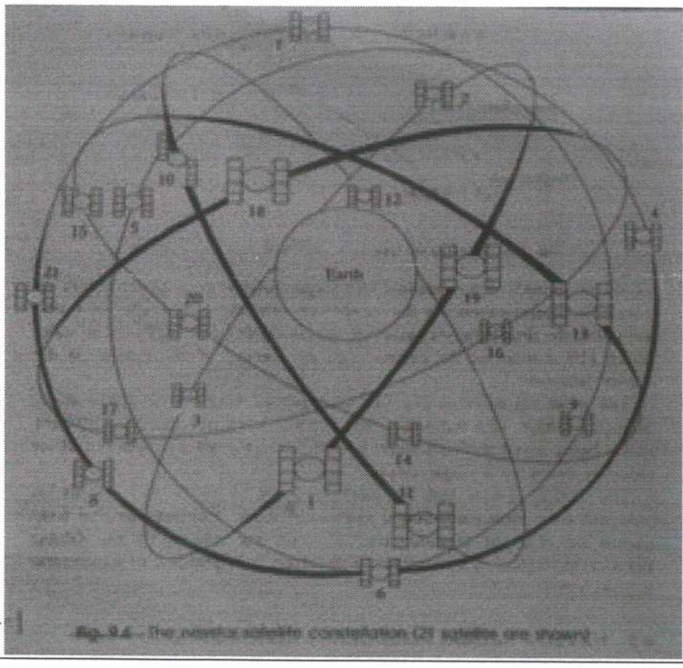
(b)	Radar displays: a. A-scope- x-axis: Range Y-axis: Target echo strength b.B-scope X-axis:Azimuth angle Y-axis:Range c. C-scope X-axis:Azimuth angle Y-axis:elevation angle d.F-scope:Centre of the display indicates the antenna's beam axis location. e.Plan Position Indicator: Target position in polar coordinates. f. Computer aided displays and printouts.	7	7	7
VI) (a)	The block diagram of a MTI radar employing a power amplifier is shown in fig. In this the coherent reference is supplied by an oscillator coho.The local oscillator is a stable oscillator called stalo. 	Fig-4 Exp-4	8	8

(b)	Tracking with radar:- Measures the coordinates of a target , predict future position. Types: Continuous tracking radar Track while scan. Single target Tracker Automatic detection and track. Phased array radar.	7	7	7
VII) (a)	Radio compass ADF uses a loop antenna in a servo feedback system. The loop antenna is coupled to the servo motor which is actuated by an error signal derived from the loop output and turns the loop until the error signal, and, therefore, the loop output is zero.The block diagram of radio compass is shown in fig. The gonio meter output is amplified and fed to a balanced modulator and modulated by a signal from the switching oscillator. The output of balanced modulator, which consists only of the sideband components, is combined with the sense aerial input. The resultant is fed to a super heterodyne amplitude modulated receiver. The reference signal and the demodulated signal are fed to Gonio motor. The motor is coupled mechanically to the Gonio meter rotor so as to the loop output is zero.  Fig. 12.20. Automatic direction finder for aircrafts.	4 4	8	8

(b)	1.Navigation by pilotage:-the navigator fixes his position on a map by observing known visible landmarks-rivers, coast-lines, hills, etc. 2.Celestial Navigation:- It is accomplished by measuring the angular position of celestial bodies. 3. 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 its motion and the time elapsed. Radio Navigation:- This method is based on the use of electromagnetic waves to fine the position of the craft.	5	5	5
VIII) (a)	VHF Omni-directional range(VOR):- This facility operates in the range 108-136MHz in the VHF band. The range transmitter radiates two patterns, distinguishable by different modulations,one of which is omni-directional and carries the modulation of a reference 30Hz sinusoid, while the second pattern is a figure-of-eight rotating at 30 rps. The radio frequency phases of the two are locked. The omni-directional radiation has a much stronger field than the figure of eight one, and therefore, the combination gives rise to a rotating cardiod. Fig shows how the phase difference between there is equal to the bearing of the receiving point from the beacon transmitter. By suitable instrumentation in the aircraft, this phase angle maybe displayed on a meter.  Fig. 3.3 Reference (R) and variable phase (V) signals of VOR received at various points	Exp-4 Dia-4	8	8

(b)	DME(Distance measuring equipment:- Both DME and TACAN are secondary radar systems. The elements of such a system are shown in fig. The system consists of a pulse transmitter and receiver(called the interrogator) carried in the craft and a pulse receiver-transmitter system (called the transponder) at a fixed position on the ground. The interrogator transmits rf pulses periodically at a frequency, say f1. These are received by the receiver of the transponder, amplified, demodulated and made to trigger the transmitter, generally after a small fixed delay. The frequency of the transmitter, say f2, is different from that of the receiver. In the craft, the receiver, which is turned to f2, receiver these pulses and the delay between the transmitted and received pulses is measured to obtain the distance of the transponder from the craft. Distance measuring equipment (DME) 	Exp-4 Fig-3	7	7
IX) (a)	The instrument landing system comprises the units localizers, glideslopes and marker beacons(as shown in fig). The localizer defines a vertical equi-signal plane which passes over the centre line of the runway and the glide slope and equi signal plane inclined to the horizontalat the desired angle of descent.The intersection of these two planes gives the approach path. Three marker beacons are also installed at certain specified distances from the end of the runway. They give an indication in the aircraft as it flies over them and thereby help the pilot to check his position in the approach path. a. Localizer:- Localizer operates in the VHF band (108-110MHz) and	Exp-10		

	consists of a transmitter with an antenna system, the radiation of which has two lobes, one with a predominant modulation of 90 Hz and the other with a predominant modulation of 150Hz. b. Glide slope system:- it operates in the band 339.3-335MHz employs two antennas. c. Marker beacons:-it give an indication in the aircraftwhen it passes over them.All of them operate at 75MHz and work with an antenna which gives a fan shaped beam which is typically +-40^0 wide along the approach path and +-80^0 perpendicular to it. ILS  Fig. 6.1 Location of the components of the instrument landing system (ILS) with respect to the runway	Fig-5	15	15
(X) (a)	INS_Inertial navigation systems:- Inertial navigation is a system of dead-reckoning navigation in which the instruments in the craft determine its acceleration and by successive integration, obtain its velocity and displacement. The essential elements of the inertial navigator are accelerometers which determine the acceleration of the craft and a set of gyroscopes which maintain the derections of the craft and a set of gyroscopes which maintain the directions of these accelerations along the desired coordinates.	Exp-4 Dia-4	8	8

	 Fig. 8.1 Block diagram of the general inertial navigation system			
(b)	**Global Positioning System(GPS):- Its working is based on the measurement of the times of arrival of the time signals received from 3 or more orbiting satellites, whose positional coordinates in space are also transmitted. There are now 21 GPS satellites including 3 spacers, in 12 hour circular orbits inclined at 55^0 to the equatorial plane, orbiting at an altitude of 20000Km, about half way lower than the geostationary satellite as shown in fig.** **GPS**  	Fig-4 exp-3	7	7