1. Explain the following
(a) Spatial resolution
(b) Spectral resolution
(c) Radiometric resolution
(d) Temporal resolution

Answer:
(a): Spatial resolution: The measure of how closely lines can be resolved in an image is called spatial resolution, and it depends on properties of the system creating the image, not just the pixel resolution in pixels per inch (ppi). For practical purposes the clarity of the image is decided by its spatial resolution, not the number of pixels in an image. In effect, spatial resolution refers to the number of independent pixel values per unit length.

The spatial resolution of computer monitors is generally 72 to 100 lines per inch, corresponding to pixel resolutions of 72 to 100 ppi. With scanners, optical resolution is sometimes used to distinguish spatial resolution from the number of pixels per inch.

In geographic information systems (GISs), spatial resolution is measured by the ground sample distance (GSD) of an image, the pixel spacing on the Earth's surface.

In astronomy one often measures spatial resolution in data points per arc second subtended at the point of observation, since the physical distance between objects in the image depends on their distance away and this varies widely with the object of interest. On the other hand, in electron microscopy, line or fringe resolution refers to the minimum separation detectable between adjacent parallel lines (e.g. between planes of atoms), while point resolution instead refers to the minimum separation between adjacent points that can be both detected and interpreted e.g. as adjacent columns of atoms, for instance. The former often helps one detect periodicity in specimens, while the latter (although more difficult to achieve) is key to visualizing how individual atoms interact.

In Stereoscopic 3D images, spatial resolution could be defined as the spatial information recorded or captured by two viewpoints of a stereo camera (left and right camera). The effects of spatial resolution on overall perceived resolution of an image on a person's mind are yet not fully documented. It could be argued that such "spatial resolution" could add an image that then would not depend solely on pixel count or Dots per inch alone, when classifying and interpreting overall resolution of an given photographic image or video frame.

(b) Spectral resolution:
The spectral resolution or resolving power of a spectrograph, or, more generally, of a frequency spectrum, is a measure of its ability to resolve features in the electromagnetic spectrum. It is usually defined by

where $\Delta\lambda$ is the smallest difference in wavelengths that can be distinguished, at a wavelength of λ.

For example, the Space Telescope Imaging Spectrograph (STIS) can distinguish features 0.17 nm apart at a wavelength of 1000 nm, giving it a resolving power of about 5,900. An example of a high resolution spectrograph is the Cryogenic High-Resolution IR Echelle Spectrograph (CRIRES) installed at ESO's Very Large Telescope, which has a spectral resolution of up to 100,000.

The spectral resolution can also be expressed in terms of physical quantities, such as velocity; then it describes the difference between velocities Δv that can be distinguished through the Doppler effect. Then, the definition is

where c is the speed of light. The STIS example above then has a spectral resolution of 51 km/s.

(c) Radiometric resolution:
While the arrangement of pixels describes the spatial structure of an image, the radiometric characteristics describe the actual information content in an image. Every time an image is acquired on film or by a sensor, its sensitivity to the magnitude of the electromagnetic energy determines the radiometric resolution. The radiometric resolution of an imaging system describes its ability to discriminate very slight differences in energy. The finer the radiometric resolution of a sensor, the more sensitive it is to detecting small differences in reflected or emitted energy.

(d) Temporal resolution: In addition to spatial, spectral, and radiometric resolution, the concept of temporal resolution is also important to consider in a remote sensing system. We alluded to this idea in section 2.2 when we discussed the concept of revisit period, which refers to the length of time it takes for a satellite to complete one entire orbit cycle. The revisit period of a satellite sensor is usually several days. Therefore the absolute temporal resolution of a remote sensing system to image the exact same area at the same viewing angle a second time is equal to this period. However, because of some degree of overlap in the imaging swaths of adjacent orbits for most satellites and the increase in this overlap with increasing latitude, some areas of the Earth tend to be re-imaged more frequently. Also, some satellite systems are able to point their sensors to image the same area between different satellite passes separated by periods from one to five days. Thus, the actual temporal resolution of a sensor depends on a variety of factors, including the satellite/sensor capabilities, the swath overlap, and latitude.

2. (a) Explain the concept of remote sensing and also explain various elements involved in remote sensing along with a neat sketch.
(b) Briefly explain application of aerial photo interpretation to terrain evaluation

Answer:
(a): Concept Of Remote Sensing: Remote sensing is the science and art of obtaining information about an object area or phenomenon through an analysis of the data

acquired by a device which is not in contact with the object, area or phenomenon under investigation. In the present context, the definition of remote sensing is restricted to mean the process of acquiring information about any object without physically contacting in any way regard less of weather the observer is immediately adjacent to the object or millions of miles away. It is further required that such sensing may be achieved in the absence of any matter in the intervening space between the object and the observer. Consequently, the information about the object, are or any phenomenon must be available in a form that can be impressed on a carrier vacuum. The information carrier, or communication link, is electromagnetic energy. Remote sensing data basically consists of wavelength intensity information acquired by collecting the electromagnetic radiation leaving the object at specific wavelength and measuring its intensity.

(b):

Fields Of Application:

The interpretation aspects of aerial photos have a wide ranging utility value in several fields. In engineering they arc used to obtain a very quick, economical and reliable assessment of ground conditions. This will facilitate the location of communication lines, canals and site location of airports, towns, industries, dams and harbours. It is also put to effective use in the study of water resources including ascertaining of ground water potential and flood control. In the field of geology aerial photo techniques arc used for mineral exploration and mining. Its use in the agricultural surveys is of very great importance because of the necessity of putting the land to its best use in view of the increasing need for food and fibres. They also help in the appraisal of soil resources, landuse and land capability. In the field of forestry aerial photographs arc used to take an inventory of forests in terms of species of trees and vegetational mapping. These techniques provide us with a simple and economical method of preparing detailed maps for urban and regional planning and development. It also facilitates the determining of the best means of developing new areas, services, facilities and policies to the ultimate benefit of humanity.

3. Explain the following earth resources satellite
(a) LANDSAT
(b) NOAA

Answer:

(a) LANDSAT

Landsat was not a large project by the standards of the program to put human beings in space, but it involved broader concerns for NASA and a large-project management style. Landsat gained public attention, and a Collier Trophy, because it symbolized a wish that the space program would bring more obvious benefits on earth. NASA leaders sought to respond to such concerns from Congress and the general public by playing up the idea that Earth resources satellites could serve the public good, while at the same time promising quick commercialization. But this commitment lacked stamina; NASA leaders still saw space exploration as the core mission of the agency, and the agency tended to further define that mission as research and development only, not operational data collection or promoting use of the resulting data. Landsat became a project intended to provide political or bureaucratic capital to NASA and its supporters, and those motivations further complicated the problem of balancing the needs of researchers and of potential operational users.

The project found itself repeatedly strangled in the budget process and by conflicts with the user agencies, even after it had (in the eyes of participants) "succeeded magnificently from a scientific and engineering sense. Most of the scientists and engineers involved at the working level committed themselves wholeheartedly to developing the possibilities for a civilian earth-observation satellite to serve the public good. But funding for the project and approval of subsequent steps was repeatedly caught up in conflicts both between NASA, the Office of Management and Budget, and Congress over funding and between NASA and the agencies that would use the data over the future of the project.

(b) NOAA

Several generations of satellites in the NOAA series have been placed in the orbit. The satellites NOAA-6 through NOAA-10 contained Advanced Very High Resolution Radiometer (AVHRR). The even numbered missions have day light north-to-south equatorial crossing and the odd numbered missions have night time north-to-south equatorial crossing. Apart from routine vegetation dynamics, flood monitoring, regional soil moisture analysis , dust and sandstorm monitoring, forest wild fire mapping ,sea surface temperature mapping, and various geological applications, including observation of eruptions and mapping of regional drainage and physiographic features.

Three of the older NOAA weather satellites which have been decommissioned and are tumbling freely are known to sporadically put out a carrier on 137.500 MHz. The satellites are TIROS-N, NOAA 6 and NOAA 9 When the relevant footprints overlap this will cause interference to NOAA 17 when active on this frequency.

4th June 2010 update for NOAA 9.

Mike Piper from Oregon has provided an interim update suggesting that there are signs that the tumbling which had hit a slow point is beginning to speed up again and that interference may be a bit less. He hopes to have a further update soon after more investigation.

NOAA 16's APT transmission system failed a few months after launch.

Metop-A's A-side LRPT transmitter has failed. Currently the redundant B-side transmitter is off until further notice (No further service expected due to interference with HIRS instrument).

NOAA 14 was decommissioned on 23rd May 2007.

NOAA 12 was decommissioned on 10th August 2007.

Signals have been reported from Meteor M N1 but they are sporadic with periods off. Although classed as LRPT it does not conform to the CGMS standard.

NOAA 17 has scan motor problems with rising motor currents.

Constant rephase by the MIRP was causing data dropouts on all the HRPT Stream and APT and GAC derivatives.

Auto re-phase has now been disabled and the resulting AVHRR products are almost all unusable. Daily MIRP rephasing via the Stored Command Table began on 18 May 2010 (10/138) - at the first pass over the South Pole each day.

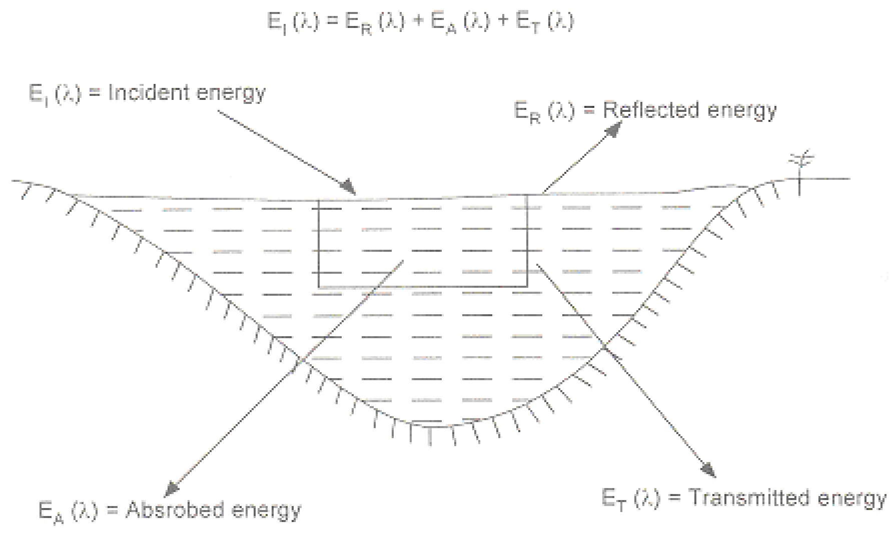
Update 29/09/10 :- Further deterioration in scan motor performance with no useable data from the AVHRR instrument. Scan motor has stalled.

As of 12th October 2010 at 15.00 UTC the following APT frequencies

4. Explain the following
(a) Energy interactions in the atmosphere
(b) Energy interactions with earth surface features.

Answer:
(a) No answer

(b) Electromagnetic energy interactions with earth surface:
When electro magnetic energy is incident on any feature of earth's surface, such as a water body, various fractions of energy get reflected, absorbed, and transmitted as shown in fig. Applying the principle of conversation of energy,



Basic interactions between Electromagnetic Energy and a water body.

$E_I(\lambda) = E_R(\lambda)+E_A(\lambda)+E_T(\lambda)$.

Where, E_I = Incident energy
E_R = Reflected energy
E_A= Absorbed energy
And, E_T = Transmitted energy

All energy components are functions of wavelength, (I). In remote sensing, the amount of reflected energy $E_R(\lambda)$ is more important than the absorbed and transmitted energies. There fore, it is more convenient to rearrange these terms like

$E_R(\lambda) = E_I(\lambda) - [E_A(\lambda)+E_T(\lambda)]$ . . . . (i)

Eq^n (i) is called balance equation. From this mathematical equation, two important points can be drawn. Firstly,

$[E_R(\lambda)/E_I(\lambda)] = [E_I(\lambda)/ E_I(\lambda)] - \{[E_A(\lambda)/E_I(\lambda) + [E_T(\lambda)/E_I(\lambda)]\}$ . . . . (ii)

According to principles of physics, it is known that

$(E_R(\lambda) /E_I(\lambda))$; $E_A(\lambda)/E_I(\lambda)$ and $E_T(\lambda)/E_I(\lambda)$ are called reflectance, absorbance and transmittance and can be denoted as $\rho(\lambda)$, $\alpha(\lambda)$, and $\gamma(\lambda)$.

Simply, it can be understood that, the measure of how much electromagnetic radiation is reflected off a surface is called its reflectance. The reflectance range lies between 1 and 1. A measure of 1.0 means that 100% of the incident radiation is reflected off the surface, and a measure ‘0’ means that 0% is reflected. The reflectance characteristics are quantified by “spectral reflectance, $\rho(\lambda)$ which is expressed as the following ratio:

$\rho(\lambda) = E_R(\lambda)/E_I(\lambda)$

$$= \frac{\text{energy of wavelength '}\lambda\text{' reflected from the object}}{\text{energy of wavelength '}\lambda\text{' incident upon the object}} \quad \text{. . . . .(iii)}$$

Eq^n (ii) can be written as

$\rho(\lambda) = 1-[\,\alpha(\lambda)+\gamma(\lambda)]$ . . . . (iv)

Since, almost all earth surface features are very opaque in nature, the transmittance $\gamma(\lambda)$ can be neglected. According to Kirchhoff's law of physics, the absorbance is taken as emissive(ξ). There fore equation (iv) becomes

$P(\lambda) = 1- \xi(\lambda)$ . . . .(v)

The fundamental equation by which the conceptual design of remote sensing technology is built. If $\xi(\lambda)$ is a zero, then $\rho(\lambda)$, that is, the reflectance is one, which means, the total energy incident on the object is reflected and recorded by sensing systems. The classical example of this of the type of object is snow. If $\xi(\lambda)$ is one, then (λ) is a zero indicating that whatever the energy incident on the object, is completely absorbed by that object.

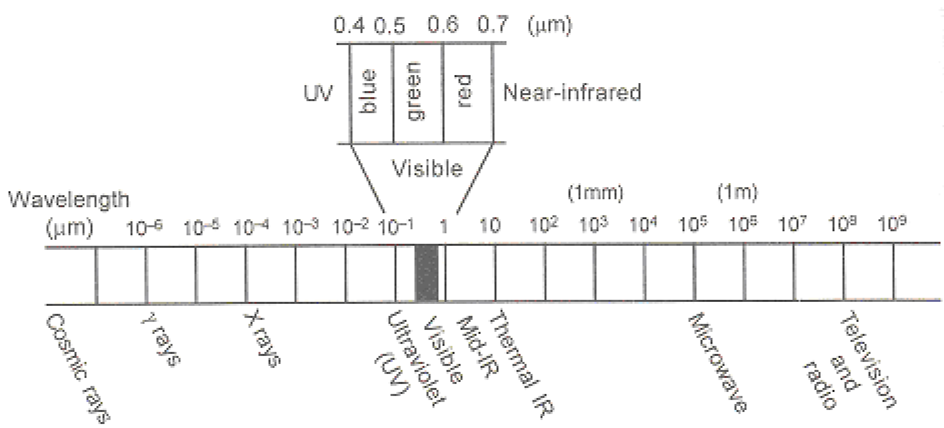
5. a. Describe the electromagnetic spectrum.
b. Write notes on the basic concepts of remote sensing. (8+8)

Answer:
(a): The electro magnetic spectrum may be defined as the ordering of the radiation according to wavelength, frequency, or energy. The wavelength, denoted by λ, is the distance between adjacent intensity maximum (for example) of the electromagnetic wave, and consequently, it may be expressed in any unit of length. Most commonly wavelength and consequently, it may be expressed in any unit of length. Most commonly wave length is expressed in meters (m) or centimeters (cm); microns or micrometers (μ or μ m = 10^{-4} cm); nanometers (nm = 10^{-7}); or Angstrom units (Å= 10^{-8} cm). The frequency denoted by υ, is the number of maxima of the electro magnetic wave that passes a fixed point in a given time. Its relation ship to wavelength is simply,

$\upsilon = C/\lambda$

where, C is the speed of light. Frequency is commonly expressed in reciprocal centimeters, also called wave numbers (cm^{-1})or cycles per second (cps) which are also called Hertz (Hz). The wavelengths may assume any value, although for most from the cosmic ray to the audio range. However, wave lengths as long as 10^{11}m have been detected by sensitive magnetometers.

It is all generated by electrically charged matter. However, there is no universal radiation generator that provides a useful intensity of radiation at all wavelengths for practical purposes, and there is no universal wave length resolving instrument or universal detector. Consequently, the spectrum has been divided into regions that bear names related to the sources that produce it, such as, the “ray” regions, or according to the visible range such as, the ultraviolet and the infrared regions, or according to the way in which wavelengths in a range are used such as, radio and television. The extent of the wavelength ranges corresponding to these names were made mostly on the basis of the limits imposed by the human eye(visible), the properties of optical materials, and the response limits of various sources and detectors.



Electromagnetic Spectrum.

(b): Basic concepts of remote sensing:
Remote sensing is the science and art of obtaining information about an object area or phenomenon through an analysis of the data acquired by a device which is not in contact with the object, area or phenomenon under investigation. In the present context, the definition of remote sensing is restricted to mean the process of acquiring information about any object without physically contacting in any way regard less of weather the observer is immediately adjacent to the object or millions of miles away. It is further required that such sensing may be achieved in the absence of any matter in the intervening space between the object and the observer. Consequently, the information about the object, are or any phenomenon must be available in a form that can be impressed on a carrier vacuum. The information carrier, or communication link, is electromagnetic energy. Remote sensing data basically consists of wavelength intensity information acquired by collecting the electromagnetic radiation leaving the object at specific wavelength and measuring its intensity.

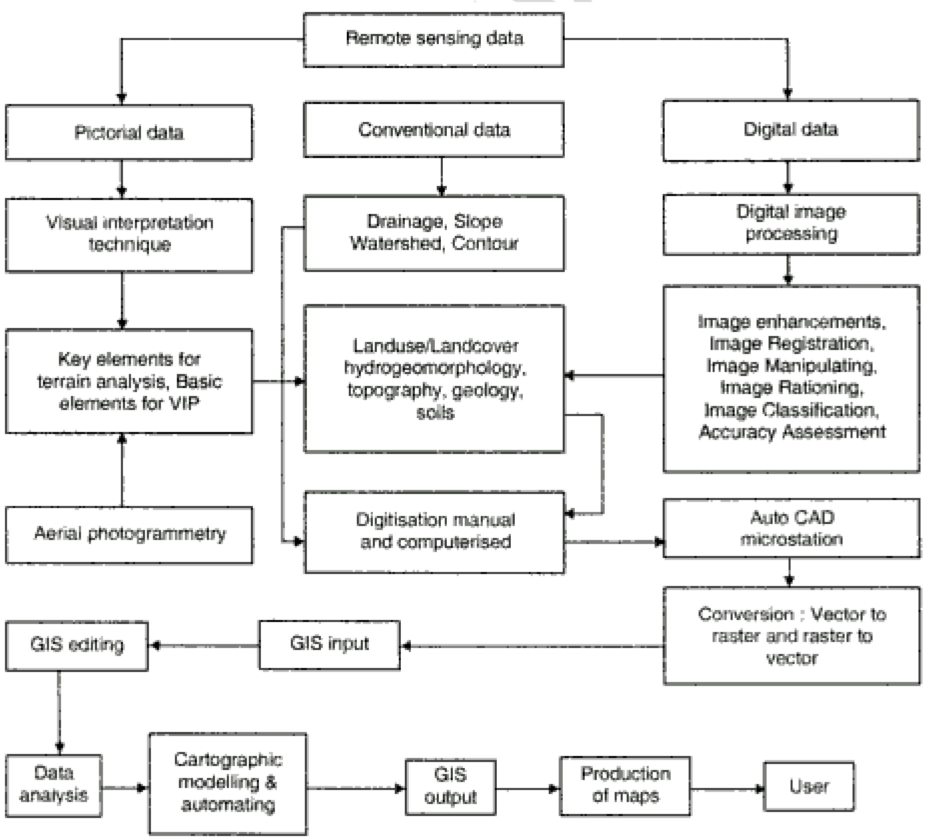
6. a. Explain the electromagnetic remote sensing process.
b. Describe the overview of linkage of remote sensing and GIS. (10+6)

Answer:
(a): The generalised processes involved in electromagnetic remote sensing system or passive remote sensing system, namely, data acquisition and data analysis are outlined below and a schematic diagram of electro-magnetic remote sensing process is shown in

fig. The data acquisition process comprises distinct elements, namely, (i) energy sources, (ii) propagation of energy through the atmosphere, (iii) energy interactions with earth's surface features (iv) airborne sensors to record the reflected energy and (v) generation of sensor data in the form of pictures or digital information. These elements are described in detail further in this chapter.

The data analysis process involves examining the data using various viewing instruments to analysis pictorial data which is called the 'visual image interpretation techniques'. Use of computers to analyse digital data through a process is known as digital image processing techniques. The analysis of a data utilizing visual image interpretation involves use of the fundamental picture elements, namely tone, texture pattern, size and shape in order to detect and identify various objects. Areal or satellite imagery are seen through stereoscopic instruments today for visual interpretation and for transferring the details on to base maps. If the data is available in digital form, it can be analysed on interactive computer systems for extracting statistical data or classified to obtain thematic information about resources. The scene is interactively analysed using computers by comparing with the actual "signature" of the object collected through field visits. This system of classification of objects is quite accurate and depends on the dispersion of training data sets over the area of the scene.

(b): Linkage of remote sensing and GIS:



7. a. State the electromagnetic spectral regions.
b. Write the advantages of remote sensing. (12+4)

Answer:
(a): Electromagnetic spectral regions

Region	Wave length	Remarks
Gamma Ray	<0.03 nm	Incoming radiation is completely absorbed by the upper atmosphere and is not available for remote sensing.
X- ray	0.03 to 3.0 nm	Completely absorbed by atmosphere. Not employed in remote sensing.
Ultraviolet	0.3 to 0.4 µm	Incoming wavelengths less than 0.3 µm are completely absorbed by ozone in the upper atmosphere.
Photographic UV band	0.3 to 0.4 µm	Transmitted through atmosphere. Detectable with film and photo detectors, but atmospheric scattering is severe
Visible	0.4 to 0.7 µm	Imaged with film and photo detectors. Includes reflected energy peak of earth at 0.5 µm
Infrared	0.7 to 1.00 µm	Interaction with matter varies with wavelength. Atmospheric transmission windows are separated.
Reflected IR band	0.7 to 3.0 µm	Reflected solar radiation that contains information about thermal properties of materials. The band from 0.7 to 0.9 µm is detectable with film and is called the photographic IR band.
Thermal IR	3 to 5 µm band	Principal atmospheric windows in the 8 to 14 µm thermal region. Images at these wavelengths are acquired by optical mechanical scanners and special vidicon systems but not by film. Microwave 0.1 to 30 cm longer wavelengths can penetrate clouds, fog, and rain. Images may be acquired in the active or passive mode.
Radar	0.1 to 30 cm	Active form of microwave remote sensing. Radar images are acquired at various wavelength bands.
Radio	> 30 cm	Longest wavelength portion of electromagnetic spectrum. Some classified radars with very long wavelengths operate in this region.

(b):