1. Advantages of geostationary satellites

Stem: Which of the following is an advantage of a geostationary satellite communication system when compared to a terrestrial system providing an equivalent service:

Correct answers:

1) It can provide high capacity communications over a long range.
2) It can provide communications coverage for a large part of the Earth's surface with minimal infrastructure.
3) It can provide a high quality communications link that is available for over 99% of the time.
4) It can provide a reliable communications link with small fade margins.

Incorrect answers:

5) It can provide long range communications without the need for a repeater.

   This is an advantage of sky wave communications which uses the ionosphere to bounce signals back to Earth. The satellite is used as a repeater in geostationary satellite systems.

6) It can use terrain, such as nearby hills and mountains, to prevent the interception of communications signals by others.

   This is an advantage of terrestrial line-of-sight communications systems. Since the position of the satellite is known, the downlink signal from the satellite can be intercepted by anyone with a receiver located in the footprint of the satellite.

7) It can provide a small delay (< 150 ms) between transmission and reception of a signal.

   This is an advantage of an undersea optic fibre communications system. Distances travelled by the electromagnetic waves to and from a geostationary satellite result in a round trip delay time of approximately 500 ms.

8) Transmitter and receiver equipment used in the system can be easily maintained and serviced so inexpensive components can be used.

   This is an advantage of terrestrial systems. Satellite components cannot be serviced once deployed in geostationary orbit so expensive components must be used to provide a suitable level of redundancy.

9) Repeaters can be situated so that terrain, such as nearby hills and mountains, will shield any potential jamming signals.

This is an advantage of terrestrial systems. Since the position of the satellite is known, a jamming signal can be directed at the satellite from anywhere within the footprint of the satellite.

2. Disadvantages of geostationary satellites

Stem: Which of the following is a disadvantage of a geostationary communication satellite system when compared to a terrestrial system providing an equivalent service:

Correct answers:

1) Almost every aspect of the system is expensive due to the requirement for redundancy and system complexity.
2) The distances that electromagnetic waves must travel between the transmitter and the receiver result in a round trip delay time of approximately 500 ms.
3) Terrain, such as nearby hills and mountains, cannot be used to prevent the interception of communications signals by others.
4) Repeaters cannot be situated so that terrain, such as nearby hills and mountains, will shield any potential jamming signals.
5) Since service and maintenance are not possible once the repeaters are deployed, a high level of redundancy is required.

Incorrect answers:

6) The communications capacity is limited due to the small available bandwidth.

   This is a disadvantage of skywave communications since the frequencies which will refract off the ionosphere are limited to between 2 and 20 MHz.

7) A large amount of infrastructure is required to provide coverage of the majority of the Earth's surface.

   This is a disadvantage of undersea fibre optic cable and terrestrial line-of-sight communications systems. A geostationary satellite system can provide communications coverage to approximately 42% of the Earth's surface with a single satellite repeater.

8) Due to the unpredictable nature of the radio path, a large fade margin must be included in the system to account for variations in the radio path loss.

   This is a disadvantage of terrestrial line-of-sight communications systems. In comparison, satellite radio path losses are much more predictable.

9) Due to the variation of the wireless channel, the communications link must be constantly monitored and transmission frequencies need to be adjusted to suit the channel.

This is a disadvantage of skywave communications. The frequencies used for the wireless channel between an earth station and a geostationary satellite are fixed and do not need to be adjusted.

3. Upper and lower atmosphere

Stem: Choose the region of the atmosphere in which the following issues, that affect a satellite system, occur:

1) Particles such as dust and water droplets attenuate the power of the electromagnetic wave passing through this region.

   Troposphere

2) Adverse weather and turbulence in this region can cause problems during the launch of a satellite.

   Troposphere

3) Variation in the refractive index, which is referred to as *scintillation*, attenuates the power of an electromagnetic wave passing through this region.

   Ionosphere

4) The aerodynamic drag of this region causes gradual decay of satellites in low orbits.

   Ionosphere

Incorrect answers:

Stratosphere

Magnetosphere

4. The vacuum of space: management strategies

Stem: Choose the effect of the vacuum of space which is addressed by the following management strategies:

1) Using appropriate materials to manufacture the components used in the spacecraft.

   Sublimation and vaporisation

2) Carefully controlling the spacecraft temperature.

   Sublimation and vaporisation

3) Careful design of the components used in the spacecraft.

   Outgassing

4) Quality control during manufacture of the components used in the spacecraft.

   Outgassing

5) Bearings and rotary joints are made of ceramic materials.

   Cold welding

6) Bearings and rotary joints are enclosed in insulated pressurized enclosures with components separated by special lubricants.

   Cold welding

Incorrect answers:

Annealing

Ingassing

5. The vacuum of space: advantages

Stem: Which of the following is an advantage of operating in a vacuum for space-based systems:

Correct answers:

1) Metal structures do not corrode in a vacuum.
2) The vacuum of space is a good insulator.
3) The absence of wind in a vacuum means there are few structural disturbances in space.

Incorrect answers:

4) In a vacuum, solids do not easily convert into a gas.

   In a vacuum, metals and semiconductors tend to *sublimate*, i.e. solids convert into a vapour, which causes the loss of material from the satellite structure.

5) Surfaces in direct contact in a vacuum do not have a layer of gas separating them so lubricants are not required.

   Surfaces in direct contact in a vacuum do not have a layer of gas separating them and a process called *cold welding* causes the surfaces to diffuse into one another and to bind solidly.

6) Pockets of gas trapped in metals during manufacture increase the strength of the component when placed in a vacuum.

If pockets of gas are trapped in components during manufacture, the trapped gas expands in a vacuum and can cause structural failure. This is known as *outgassing*.

6. Temperature of space, meteoroids and radiation

Stem: Choose the aspect of the space environment which causes the following undesirable effects on a spacecraft.

1) Extreme variations in the temperature of equipment on board the spacecraft.

   Solar eclipse

2) Structural damage to the spacecraft.

   Impact of meteoroids and space debris

3) A sand-blasting effect on the surfaces of the spacecraft.

   Prolonged impact of micro-meteoroids

4) A change in the molecular bonds of materials affecting emissivity and absorption properties of the materials.

   Ultraviolet radiation

5) Transparent materials become opaque.

   Ultraviolet radiation

6) A change in the crystalline structure of semiconductors and insulating materials which affect the characteristics of electronic devices.

   Electromagnetic radiation

7) An excess of electrical charge accumulates on the surfaces of the spacecraft.

   Corpuscular radiation

Incorrect answers:

The Earth's magnetic field

The vacuum of space

The Earth's gravitational field

7. Satellite subsystems

Stem: Choose the satellite subsystem which corresponds to the following functional descriptions:

1) Receive, frequency translate, amplify and retransmit an electrical signal.

   Communications

2) Focus the power of an electromagnetic wave on a portion of the Earth's surface.

   Antenna

3) Generate, store and distribute electrical power to other subsystems on board the satellite.

   Power

4) Provide the framework for mounting the other satellite subsystems and the interface with the launch vehicle.

   Structural

5) Maintain the temperature of the spacecraft within the operating limits of the equipment on board.

   Thermal Control

6) Determine the position of the spacecraft, collect and transmit health information for the other subsystems, receive and execute remote control commands.

   Tracking, Telemetry and Command

7) Control the orbital path and ensure the antennas remain pointed at the correct location on the Earth's surface.

   Attitude and Orbit Control

8) Circularise the final orbit of the satellite during launch and regularly reposition the satellite to compensate for orbital variations.

   Thrust

Incorrect answers:

Shielding

Energy

Communications, Command and Control

8. Satellite stabilization

Stem: Choose the stabilisation method which best corresponds to the following advantages and disadvantages:

1) When this method is used, solar panels mounted on the cylindrical platform do not always face the sun.

   Spin

2) This method allows the use of large flat solar panels that are always oriented towards the sun.

   Three-axis

3) This method cannot provide a precise pointing capability.

   Gravity Gradient

4) This method is only suitable for use on satellites in a low Earth orbit.

   Gravity Gradient

5) The cost of this method is low because no fuel needs to be carried.

   Gravity Gradient

6) This method is vulnerable to bearing failure.

   Spin

Incorrect answers:

Magnetic Boom

Station Keeping

9. User systems

Stem: Choose the type of satellite service that best corresponds to the following service descriptions:

1) Satellites relay signals between large Earth stations to provide long distance trunk connections.

   Fixed Satellite Service (FSS)

2) Television signals from a large Earth station are broadcast via a satellite to relatively simple receive-only Earth stations.

   Broadcasting Satellite Services (BSS)

3) Narrowband voice and low-speed data signals are relayed between large Earth stations and small mobile terminals via satellites in geostationary orbit.

   GEO Mobile Satellite Service (MSS)

4) Narrowband low-speed data signals are relayed between large Earth stations and small mobile terminals via satellites in low Earth orbit.

   Little-LEO Mobile Satellite Service (MSS)

5) Narrowband voice and low-speed data signals are relayed between large Earth stations and small mobile terminals via satellites in low Earth orbit, medium Earth orbit or highly elliptical orbit.

   Big-LEO Mobile Satellite Service (MSS)

6) Broadband multimedia signals are relayed between large Earth stations and small mobile terminals.

   Super-LEO Mobile Satellite Service (MSS)

Incorrect answers:

Trunk Satellite Service (TSS)

Personal Communications Service (PCS)