Elastic Media and Elastic Waves

1. What is a homogeneous/non-homogeneous, isotropic/anisotropic medium?

- **Homogeneous Medium**: A medium where properties (e.g., density, elasticity) are the same throughout. Example: Pure quartz.
- **Non-Homogeneous Medium**: A medium where properties vary spatially. Example: Sedimentary rock layers with different compositions.
- **Isotropic Medium**: A medium where properties are identical in all directions. Waves travel at the same speed regardless of direction.
- **Anisotropic Medium**: A medium where properties change with direction. Example: Crystals or layered geological formations, where wave velocity depends on the direction of propagation.

2. What are P- and S-waves: velocity and polarization?

- **P-Waves (Primary Waves)**:
    - Longitudinal or compressional waves.
    - Particle motion is **parallel** to wave propagation.
    - Fastest seismic wave, travels through **solids, liquids, and gases**.
    - Velocity:

$$V_p = \sqrt{\frac{k + \frac{4\mu}{3}}{\rho}}$$

    where K is the bulk modulus, μ is the shear modulus, and ρ\rho is density.

- **S-Waves (Secondary Waves)**:
    - Transverse or shear waves.
    - Particle motion is **perpendicular** to wave propagation.
    - Only travels through **solids** (since fluids cannot support shear stress).

    Velocity:

$$V_s = \sqrt{\frac{\mu}{\rho}}$$

3. What are surface waves?

- **Waves that travel along the surface of a medium**, decreasing in amplitude with depth.

- **Two main types**:
    - **Rayleigh waves**: Elliptical particle motion, causing both vertical and horizontal displacement.
    - **Love waves**: Horizontal shear motion, causing significant ground movement.
- **Applications**: Used in seismic surveys and telecommunications for surface-based signal propagation studies.

4. What is acoustic media?

- A medium in which pressure waves (P-waves) can propagate.
- **In fluids (liquids and gases)**, only P-waves exist (no shear waves).
- **In solids**, both P-waves and S-waves propagate.
- Used in **ultrasound, underwater acoustics, and telecommunications applications** like SONAR and ultrasonic transducers.

5. What happens at the interface between two media: scatter coefficients?

- When a wave encounters a boundary between two materials, it undergoes **reflection, transmission, and refraction**.
- The **reflection coefficient R** and **transmission coefficient T** are calculated using:

$$R = \frac{z_2 - z_1}{z_2 + z_1}, T = 1 + R$$

- Used in radar, sonar, and medical imaging applications.

6. What causes wave amplitude attenuation?

- **Geometric spreading**: Energy spreads out over a larger area as the wave propagates.
- **Intrinsic absorption**: Energy is lost as heat due to the internal friction of the medium (quantified by the quality factor Q).
- **Scattering**: Part of the wave energy is deflected in different directions when encountering irregularities.

7. What are the measured variables and output display?

- **Measured variables**:
    - Wave velocity, amplitude, frequency, phase, travel time.
- **Output formats**:
    - Seismic traces, wavefield snapshots, spectrum analysis graphs.

Electrical Methods

1. What are the principles?

- Electrical methods measure **subsurface resistivity** by injecting current into the ground and measuring voltage differences.
- Governed by **Ohm's Law**: $J = \sigma E$ where J is the current density, σ is conductivity, and E is the electric field.

2. What equipment is used?

- **Current electrodes**: Inject current into the ground.
- **Potential electrodes**: Measure the voltage difference.
- **Multimeters and georesistivity meters**: Record data.

3. How to build a pseudosection?

- A **pseudosection** is a 2D representation of apparent resistivity.
- Steps:
  - Collect resistivity measurements using different electrode spacings.
  - Arrange data in a depth plot, assuming greater depth for larger electrode spacing.

4. What are apparent and true resistivity?

- **Apparent resistivity (ρ_a)**: Measured resistivity assuming a homogeneous medium.
- **True resistivity (ρ_t):)**: Actual subsurface resistivity obtained through inversion techniques.

5. What are the measured variables and output display?

- **Variables**: Voltage, current, resistivity.
- **Output**: Pseudosections, depth-resistivity profiles.

Electromagnetic Methods

1. What are EM parameters?

- **Electrical conductivity (σ)**: Ability to conduct electricity.
- **Magnetic permeability (μ)**: Response to a magnetic field.
- **Dielectric permittivity (ε)**: Response to an electric field.

2. What are low and high-frequency measurements?

- **Low frequency (e.g., magnetotellurics, VLF methods)**: Penetrates deeper.
- **High frequency (e.g., Ground Conductivity Meters, GPR)**: Limited penetration, higher resolution.

3. What are the applications?

- Used in geophysical exploration, detecting underground utilities, and environmental assessments.

4. What equipment is used?

- **Ground conductivity meter**: Measures conductivity to map subsurface variations.
- **Metal detector**: Finds buried metallic objects based on induced eddy currents.

5. What are the measured variables and output display?

- **Variables**: Magnetic field strength, phase shift, conductivity.
- **Output**: Conductivity-depth profiles, subsurface maps.

Ground Penetrating Radar (GPR)

1. What are the principles?

- GPR transmits **high-frequency electromagnetic waves** into the ground.
- Reflections occur at material boundaries with different **dielectric permittivity**.

2. What are the applications?

- Used for **utility detection, archaeological surveys, structural assessment, and environmental studies**.

3. What is the link between antenna frequency, penetration depth, and resolution?

- **Higher frequency**:
    - Better resolution, but lower penetration.
    - Used for detecting shallow objects (e.g., cables, concrete assessment).
- **Lower frequency**:
    - Greater penetration, but lower resolution.
    - Used for deeper targets (e.g., groundwater, void detection).

4. What are the measured variables and output display?

- **Variables**: Reflection amplitude, two-way travel time, depth.
- **Output**: Radargrams (amplitude vs. travel time), depth slices, 3D subsurface models.