- **Introduction to Earthquake Faulting and Seismic Waves**
    - Lecture 1 of 4 on earthquake hazards
    - Foundation for the module
    - Split into two parts:
        - Study of faults and the earthquake cycle
- **Earthquake Cycle and Faults**
    - Concept of periodic build-up and release of stress on faults
    - Example: magnitude 7.8 Kaikoura earthquake (November 2016, New Zealand)
        - Surface rupture: pronounced linear trend of deformation
        - Common misconception: surface ruptures are not chasms; adjacent blocks slip past each other
    - **Observation of Surface Ruptures**
        - Offset roads indicate slip along a fault
        - Visual cues: fences and stream channels cut by faults
- **Fault Characteristics**
    - Fault scarp: landform resulting from vertical offset
    - Surface rupture indicates where the fault intersects Earth's surface
    - Importance of understanding that earthquakes involve slip along faults, not just points.
- **Kaikoura Earthquake Dynamics**
    - Involvement of about a dozen different faults
    - Slip movement observed along the Kekarengu fault
    - Epicenter: point where slip starts; just a reference point
- **Fault Plane Features**
    - Fault planes exhibit corrugations and striations from repeated slip
    - Smooth, polished surfaces from earthquake slip
    - Seismogenic zone: typically 10-20 kilometers deep; varies in subduction zones
- **Types of Faults**
    - **1. Reverse Faults**
        - Thrusting motion, leading to shortening and crustal thickening
        - Dip angle varies; classified as thrust faults if very low
        - Example: Chi-Chi earthquake (1999, Taiwan) and Himalayan thrust fault
    - **2. Normal Faults**
        - One side slides down leading to extension and crustal thinning
        - Typically steeper than reverse faults
        - Examples: Hebgen Lake earthquake (1959) and Norcia earthquake (2016)
    - **3. Strike-Slip Faults**
        - Lateral movement with no crustal thickening/thinning
        - Can be left-lateral or right-lateral
        - Examples: Ridgecrest earthquake (2019) and Kumamoto earthquake (2016)

- **Mapping Earthquake Surface Ruptures**

    - Importance of mapping for understanding seismic hazards
    - Traditional methods vs. modern satellite imagery techniques

- **Earthquake Slip Mechanics**

    - Stick-slip behavior: cyclic build-up of stress followed by slip
    - Earthquakes cannot be predicted due to variability in slip behavior

- **Inter-Seismic and Co-Seismic Phases**

    - Inter-seismic: gradual build-up of strain, causing slight warping
    - Co-seismic: rapid release of strain leading to surface offsets
    - Example of actual fence offset from the Darfield earthquake (2010)

- **Long-term Earthquake Cycles**

    - Geological offsets represent cumulative impacts of multiple earthquakes
    - Major earthquakes re-trigger existing faults, not create new ones

- **Subduction Zone Earthquake Cycle**

    - Involves vertical and horizontal motions
    - Long-term convergence: overriding plate bulges and then rapidly releases during an earthquake
    - Tsunami generation associated with offshore uplift during co-seismic phase

- **Conclusion**

    - Overview of the mechanisms and types of faults related to earthquake dynamics and hazards.

    - **Introduction to Seismic Waves**

    - Two basic categories of seismic waves:

        - **Surface Waves**
            - Travel around the Earth's surface (analogous to ripples in a pond).
            - Slower than body waves (typically 2-3 km/s).
        - **Body Waves**
            - Pass through the Earth's interior.
            - Faster than surface waves, reaching distant points sooner.

- **Characteristics of Seismic Wave Propagation**

    - Body waves form a curved path within the Earth.
    - Material properties change with depth:
        - Silicate rocks become denser and stiffer with increasing depth.
    - Seismic wave velocities:
        - Deep mantle: fastest
        - Upper mantle: slower
        - Surface: slowest

- **Types of Body Waves**
  - **P Waves (Primary Waves)**
    - Fastest seismic waves, arrive first.
    - Particles move in the same direction as the wave (compression).
    - Can travel through liquids (e.g., molten iron outer core).
  - **S Waves (Secondary Waves)**
    - Second fastest, arrive second.
    - Particles move side-to-side, perpendicular to wave direction.
    - Cannot pass through fluids.
- **Types of Surface Waves**
  - **Love Waves**
    - Similar particle motion to S waves (side-to-side).
    - Particles at the surface move more than those at depth.
  - **Rayleigh Waves**
    - Particle motion described as a retrograde ellipse.
    - Also, particles at the surface move more than those at depth.
    - Sometimes called ground roll.
- **Seismometers and Seismograms**
  - Seismometers record ground vibrations caused by seismic waves.
    - Traditional design: weight/pendulum suspended from a frame.
  - Seismographs:
    - Instrument + recording device.
    - Seismogram: graphical representation of ground displacement over time.
    - Typically records motions along three X, Y, Z axes.
- **Identifying Seismic Waves on Seismograms**
  - P Waves: excite vertical component, arrive first.
  - S Waves: excite radial component, arrive second.
  - Surface Waves: appear later with larger amplitudes, hence more damaging.
    - Love waves: transverse component (side-to-side).
    - Rayleigh waves: excite vertical and radial components.
- **Earthquake Early Warning Systems**
  - Systems detect and locate earthquakes quickly to alert people before surface waves arrive.
  - Key to effectiveness: seismic stations surrounding the causative fault.
  - Few regions have operational early warning systems.
- **Locating Earthquakes Using Seismograms**
  - P wave travel time (Tp) < S wave travel time (Ts): Ts - Tp increases with distance.
  - Velocity: distance = time x velocity (for P and S waves).
  - Calculation example:

        - Separation time of 90 seconds, Vp = 6.0 km/s, Vs = 3.75 km/s yields a distance of 900 km to earthquake.
    - Method:
        - Plot distances on a schematic map as circles.
        - Intersection of circles locates the earthquake.

- **Global Seismology**
    - Exploits refraction and reflection of body waves at Earth's major boundaries.
        - Example: Outer core is liquid as indicated by P wave shadow zone.
    - Epicentral distance defined by angles between the earthquake, Earth's center, and distance seismometer.

- **Future Topics**
    - Discuss magnitude and intensity scales in the next lecture.
    - Explore basin resonance and detailed impacts of seismic waves during future sessions.