SEGMENT 1:

SUITABLE DESIGN FOR SAMPLE COLLECTION SYSTEM

General Overview of Soil Collection Mechanism

The soil collection mechanism consists of multiple subsystems working together to extract, transport, and store soil samples. Below are the key components and their mechanisms:

1. **Auger Drilling System (Soil Extraction)**

Components:

- **Auger Drill** : A helical blade that penetrates and loosens the soil.
- **Drill Motor** : Rotates the auger to cut into the ground.
- **Linear Actuator** : Moves the drill up and down.

Mechanism:

- The auger spins and drills into the soil, bringing particles to the surface.
- The helical shape lifts the soil upward through its spiral motion.
- Once the soil reaches the surface, the scooping mechanism and conveyor system takes over.

2. **Scooping System (Soil Collection & Transfer)**

Components:

- **Scoop or Blade** : A small bucket or flat plate that collects soil.
- **Actuator Arm or Servo Motor** : Moves the scoop to collect and dump soil.
- **Hinges or Linkages** : Enable controlled movement.

Mechanism:

- The scoop moves under or beside the auger, catching the loosened soil.
- The actuator lifts and dumps the soil into the transport system.

3. **Screw Conveyor System (Soil Transport)**

Components:

- **Screw Conveyor** : A rotating helical blade inside a tube.
- **Micro Gear Motor** : Rotates the screw to move soil.
- **Outer Casing** : Prevents soil spillage.

Mechanism:

- Soil from the scoop enters the conveyor inlet.
- The screw rotates, pushing soil upward or sideways toward the storage chamber.
- An inclined design could helps soil move efficiently with minimal energy use.

4. **Storage & Sealing System**

Components:

- **Sample Chamber** : Airtight container for storing soil.
- **Sealing Mechanism** : Rubber gaskets, O rings or mechanical locks to keep the sample sealed.
- **Sensors** : Detect soil presence or test its properties.
- **Load Cell**: Used to measure the weight.

Mechanism:

- The conveyor or scoop deposits soil into the storage unit.
- The container seals to prevent contamination.
- The sample remains secure for transport and analysis.

1. Airtight Container Design

Introduction

The proposed design is a sealed and airtight container intended for storing soil samples collected by a two-step auger drilling mechanism. The system is designed to ensure complete containment of the sample while allowing weight measurement using an external load cell without compromising airtightness.

Structure Overview:

- **Outer Shell**: Cylindrical or rectangular aluminum body for strength and lightweight.
- **Lid Mechanism**: Threaded cap or hinged lid with latch locks could be used for airtight sealing. The lid incorporates a vacuum-sealed locking mechanism to prevent leakage.
- **Sealing**: Silicone O-ring around the lid's edge for 100% airtightness.
- **Base**: Flat base to mount on the rover's science compartment and to interface with the load cell.

The detailed description of the design is given below:

1. **Material Selection**:

- Used aluminum alloy (6061-T6) for lightweight and strength.
- Used rubber or silicone gaskets for airtight sealing.

2. **Sealing Mechanism**:

- Designed a lid with an O-ring seal to ensure an airtight fit. A double O-ring system provides redundancy in airtight sealing.
- Double-checked with a compression seal using silicone gaskets for better performance.
- The container is designed to sustain vacuum conditions to prevent contamination of the soil sample.

Image: O-Rings

3. **Load Cell Integration**:

   Location: External, under the container.

   Method:

- The load cell is placed externally beneath a supporting plate where the container rests.
- The weight of the soil sample is determined by measuring the force exerted by the container on the load cell.
- The design ensures no sensors are placed inside the container to maintain its airtight nature.
- A lever arm or a cantilever system to transmit the sample's weight to the load cell.
- It is ensured that the load cell is securely mounted to avoid vibration interference.

   Mechanical Linkage: The platform was connected to the load cell using a flexure mechanism for accurate force transfer.

4. **Design Considerations**:
   - It is ensured that the container is dustproof and resistant to extreme temperatures.

   - Internal chamber is kept smooth to avoid sample sticking.

   - Easy sample insertion introduced through a hatch or valve system.

Working Method

1. The auger drill extracts soil from the surface up to a depth of 30 cm.
2. The scooping mechanism transfers a minimum of 5 grams of soil into the airtight container.
3. Once filled, the container is sealed using the O-ring and latch-lock mechanism.
4. The sealed container is placed on the external load cell platform.
5. The weight of the collected soil is measured and recorded.
6. The sample is stored securely in the science compartment of the rover body for analysis or return.

Weight Measurement Mechanism

Weighing Process

The load cell in this setup works based on the principle of strain gauges, which measure the deformation of a material when a force is applied. The weighing process is given below:

1. **Force Application (Weight of Soil Sample):**
    - The soil sample is placed in the container, which rests on a supporting plate.
    - The weight of the soil applies a downward force to the container, which is transmitted through the supporting plate to the load cell.
2. **Lever Arm or Cantilever System:**
    - A lever arm or cantilever system is used to ensure that the weight of the soil sample is transferred effectively to the load cell.
    - This mechanism amplifies the force applied by the sample, ensuring that it is accurately measured by the load cell.
3. **Deformation of Load Cell:**
    - The load cell itself is typically made of a metal material with strain gauges bonded to it.
    - When the weight of the container and soil sample is applied, the load cell deforms slightly (stretches or compresses).
4. **Strain Gauge Measurement:**
    - The strain gauges are designed to change their electrical resistance when deformed (due to the applied force).
    - As the strain gauge deforms, its resistance changes, and this change is proportional to the force applied.
5. **Signal Conversion:**
    - The change in electrical resistance is converted into an electrical signal, which is then sent to an amplifier or a microcontroller.
    - The signal is then processed and calibrated to determine the exact weight or force exerted by the soil sample.
6. **Mounting and Vibration Avoidance:**
    - The load cell is securely mounted, often with a flexure mechanism, to ensure that it measures the force accurately without interference from vibrations.
    - This helps in maintaining the precision of measurements, as vibrations or shifts could otherwise cause inaccuracies.
7. **Output (Weight of the Soil):**
   Finally, the processed signal is converted into a weight measurement, providing the mass of the soil sample placed inside the container, while keeping the container airtight.

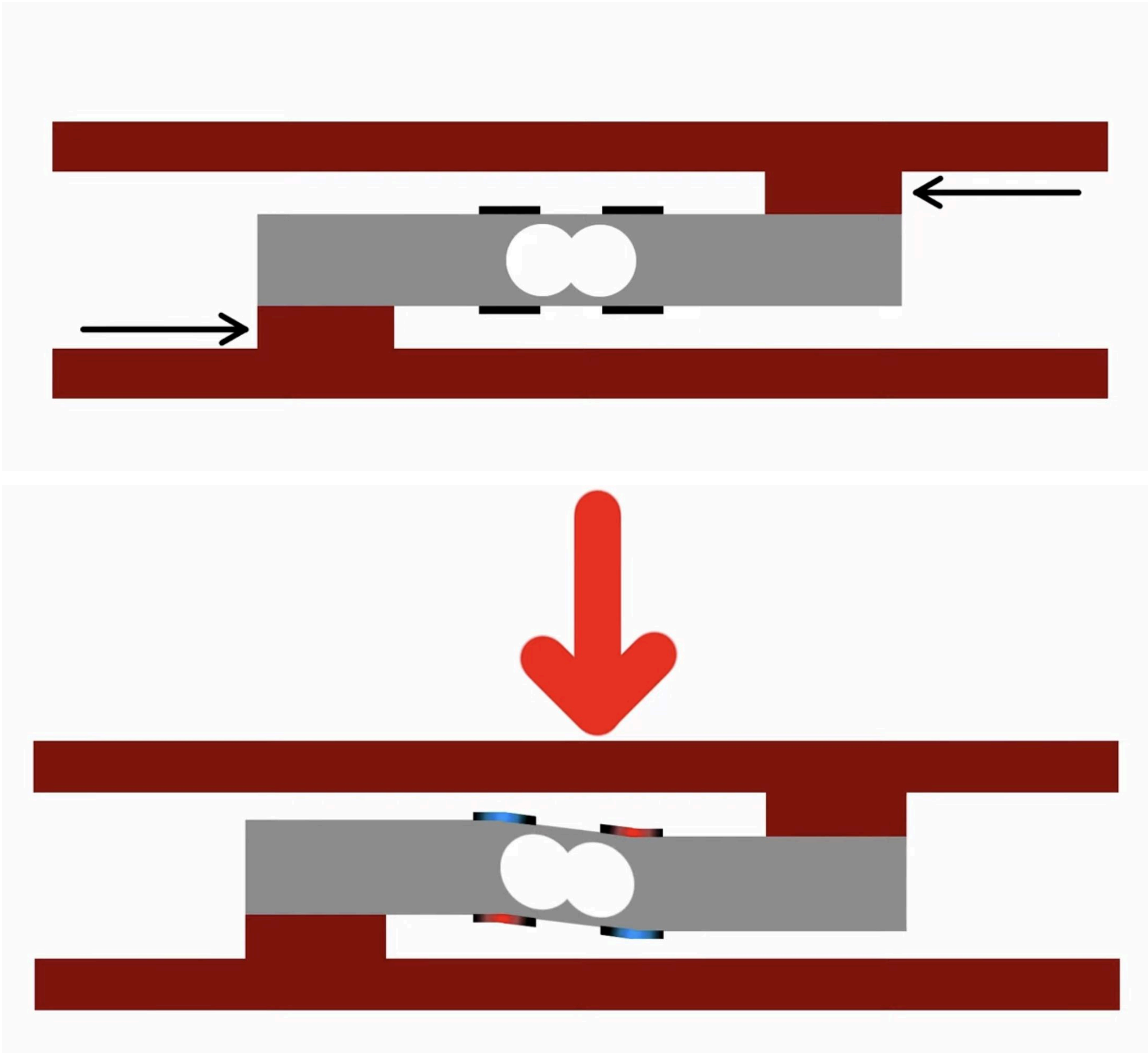

Image: Working Process of Load Cell

This method ensures that the weight of the soil is measured without compromising the container's seal, and the flexure mechanism provides a stable, vibration-resistant way to transfer the force to the load cell.

Conclusion

This design ensures complete airtight sealing of the soil sample container while integrating an external load cell for weight measurement. The mechanism is efficient, preventing contamination and ensuring accurate weight assessment without compromising the airtight integrity of the container.

2. Screw Conveyor Soil Transport System

The screw conveyor system is used to transport soil samples from the scooping or drilling mechanism to a collection chamber for further analysis.

1.Main Components

Central Shaft : A rotating rod that holds the helical screw blade.

Helical Blade : A spiral-shaped structure attached to the shaft that moves soil when rotated.

Outer Casing : A tube that encloses the screw to guide soil movement.

Motor : Drives the screw conveyor, rotating the shaft and blade.

Supports & Bearings : Hold the system in place and reduce friction.

2. Working Mechanism

Soil Entry (From Scooping Mechanism):

- The scooping mechanism collects the soil and deposits it into the screw conveyor's inlet.

Rotation & Soil Transport:

- The micro gear motor rotates the central shaft, causing the helical blade to turn.
- As the blade turns, soil particles get pushed along the screw's axis towards the outlet.
- The inclination angle of the screw helps in upward movement against gravity.

Soil Collection at the Outlet:

- The transported soil reaches the outlet.
- The soil falls into a storage container for further analysis.

3. Design Considerations

Efficiency : The pitch and rotation speed of the screw determine how fast the soil is transported.

Dust Sealing : Since Mars has fine dust, the system should be enclosed to prevent clogging.

Low Power Consumption : A micro gear motor is used to minimize power usage.

Material Choice : For Mars, lightweight materials like aluminum or carbon fiber reduce weight, but in ERC or ARC, 3D-printed ABS can work.

1. Central Shaft, Helical Blade (Auger), Outer Casing-Aluminum 6061-T6

- **Lightweight & strong**: Good strength-to-weight ratio, lightweight, sufficient strength.
- **Corrosion resistance**: Essential for dusty martian environments.
- **Machinability**: Easy to manufacture.

2. Supports & Bearings-AISI 304

- **Corrosion-resistant** : Good for humid and dusty environments.
- **Widely available in BD** : Easy to source locally.
- **Decent strength & wear resistance** : Works well for structural parts.

Component	**Material**	**Reasons to use**
Central Shaft	Aluminum 6061-T6	Strong, lightweight, corrosion-resistant.
Helical Blade	Aluminum 6061-T6	Lightweight or higher wear resistance.
Outer Casing	Aluminum 6061-T6	Strong, lightweight, dust-resistant.
Supports & Bearings	AISI 304	High wear resistance, corrosion-resistant,good for humid/dusty environments.

4. Why Use a Screw Conveyor Instead of Other Methods?

Reliable in Low Gravity : Works well in low-gravity environments like Mars, where soil might behave differently.

Controlled Soil Flow : Ensures precise movement of collected soil samples.

Reduces Spillage : Unlike belts or direct scooping, soil stays inside the enclosed system.

Why the Screw Conveyor Mechanism is Cost-Effective & Easily Manufacturable in Bangladesh?

The screw conveyor soil transport system is a practical choice for planetary rovers due to its simplicity, affordability, and ease of manufacturing. Below is an analysis of why it is cost-effective and suitable for manufacturing in Bangladesh.

Cost-Effectiveness

Simple Design & Low Material Cost:

- The central shaft with a helical blade can be made using mild steel, aluminum, or even 3D-printed plastic, all of which are readily available in Bangladesh.
- Unlike complex vacuum or pneumatic systems, the screw conveyor requires fewer components, reducing cost.

Minimal Power Consumption:

- The micro gear motor used in the conveyor has low power requirements, reducing energy costs.
- The helical design enables efficient soil transport without excessive force.

No Expensive Precision Parts Required

- Unlike vacuum-based systems, which require high-precision seals and pumps, the screw conveyor only needs a motor, shaft, and casing, all of which can be locally fabricated at a low cost.

Easy Manufacturability in Bangladesh

Availability of Materials & Fabrication Techniques:

- Steel, aluminum, and polymer materials are widely available in local markets.
- CNC machining, sheet metal fabrication, and 3D printing are accessible in Dhaka and major industrial zones.

Simple Assembly Process:

- The system consists of basic mechanical components (a rotating shaft, helical blade, and casing), making assembly straightforward.
- Welding, bolting, or 3D-printing techniques can be used, no need for advanced manufacturing setups.

Local Expertise in Screw Conveyor Fabrication:

- Rice mills, flour mills, and cement industries in Bangladesh already use screw conveyors.
- Local manufacturers can easily scale down these designs for rover applications without requiring new machinery.

Repairability & Maintenance:

- If a component fails, it can be easily replaced using locally available parts.
- No need for specialized tools, standard workshop tools are sufficient.