1️⃣ Weight Scale (HX711)

What you need: A known weight (e.g., a 5 kg dumbbell or a calibrated mass).

Steps:

1. **Tare (zero) the scale**
   - Remove all weight from the scale platform.
   - In the Serial Monitor, type w to start weight calibration.
   - The program will ask you to press any key when the scale is empty.
   - It then performs a tare – you'll see Tare completed.
2. **Place a known weight**
   - Place your known weight (e.g., 5.0 kg) on the scale.
   - Wait for the reading to stabilise (a few seconds).
   - In the Serial Monitor, enter the exact weight (e.g., 5.0) and press Enter.
3. **Compute and apply calibration factor**
   - The program reads the raw value, computes the new scale factor, and displays it.
   - Example output:

     ```
     Raw reading: 12450.123

     Known weight: 5.00 kg

     New scale factor: -7025.456
     ```

   - The factor is now stored in RAM. To save it permanently, type e later.

2️⃣ Height (Ultrasonic HC-SR04)

What you need: An object of known height (e.g., a box exactly 100 cm tall, or you can measure your own height against a wall).

Steps:

1. **Mount the sensor** at a known height (e.g., 250 cm from the floor).
   - Measure the distance from the sensor to the floor accurately with a tape measure.
   - In the main code, this value is MOUNTING_HEIGHT. You may adjust it later.

2. **Place the known-height object** directly under the sensor.
    - Ensure the object’s top surface is level and reflects ultrasound well.
3. **Run height calibration**
    - In the Serial Monitor, type h.
    - Enter the actual height of the object in cm (e.g., 100.0) and press Enter.
    - The program takes several measurements, averages them, and computes an **offset**.
    - Example output:

```
Measured height: 98.7 cm

Known height: 100.0 cm

Computed offset: 1.3 cm
```

    - The offset will be added to every future height reading to correct the error.

3️⃣ Temperature (MLX90614)

The MLX90614 is factory calibrated, but you may want to verify it against a trusted thermometer and apply a small offset if needed.

What you need: A reference thermometer (e.g., a medical infrared thermometer or a good digital thermometer).

Steps:

1. **Measure a stable temperature**
    - Point both the MLX90614 and the reference thermometer at the same object (e.g., a cup of warm water, or your own forehead).
    - Wait for readings to stabilise.
2. **Compare readings**
    - Note the reference temperature (T_ref) and the sensor reading (T_sensor).
    - The offset = T_ref - T_sensor.
3. **Apply the offset in the main code**
    - In your main sensor hub code, after reading healthData.temperature_c, add the offset:

cpp

```
healthData.temperature_c += TEMP_OFFSET;
```

   - You can store the offset in EEPROM along with other calibration values (extend the EEPROM layout).

Note: If the error is small (≤ 0.5 °C), you may skip this step, as the sensor is usually accurate enough for screening.

4️⃣ Heart Rate (MAX30102)

The MAX30102 does not require calibration in the traditional sense. However, you can verify its accuracy and adjust parameters if needed.

What you need: A finger pulse oximeter or a manual pulse count (watch + counting for 15 seconds).

Steps:

1. **Check signal quality**
   - Place your finger on the sensor. In the Serial Monitor, you should see IR values > 30 000 when a finger is present.
   - If the values are too low, increase the LED current in the code:

cpp

```
particleSensor.setPulseAmplitudeRed(0x1F);   // 0x1F is max
```

2. **Compare BPM readings**
   - Let the sensor run for 30 seconds and note the displayed BPM.
   - Simultaneously count your pulse manually (e.g., for 15 seconds and multiply by 4).
   - The two values should be within ±5 BPM.
3. **Adjust the finger detection threshold**
   - In updateHeartRate(), you have #define FINGER_THRESHOLD 30000.
   - If the sensor often loses the finger, lower the threshold (e.g., to 20000).
   - If it triggers on noise, raise it.
4. **No permanent calibration factor** – the heart rate algorithm is self-adjusting.

💾 Saving All Calibration Data

After you finish all calibrations, type e in the Serial Monitor. The program will write:

- Scale factor
- Tare offset
- Height offset
- (Optional) temperature offset

to EEPROM. Then upload your **main sensor hub code** (the one with streaming and commands). That code reads the EEPROM at startup and applies the saved values automatically.

🔁 Re-calibration

You can run the calibration sketch again anytime. It will load the previously saved values, allow you to modify them, and save again with e.