Assignment 1:

EEE3088F – Engineering design principles

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Questions:

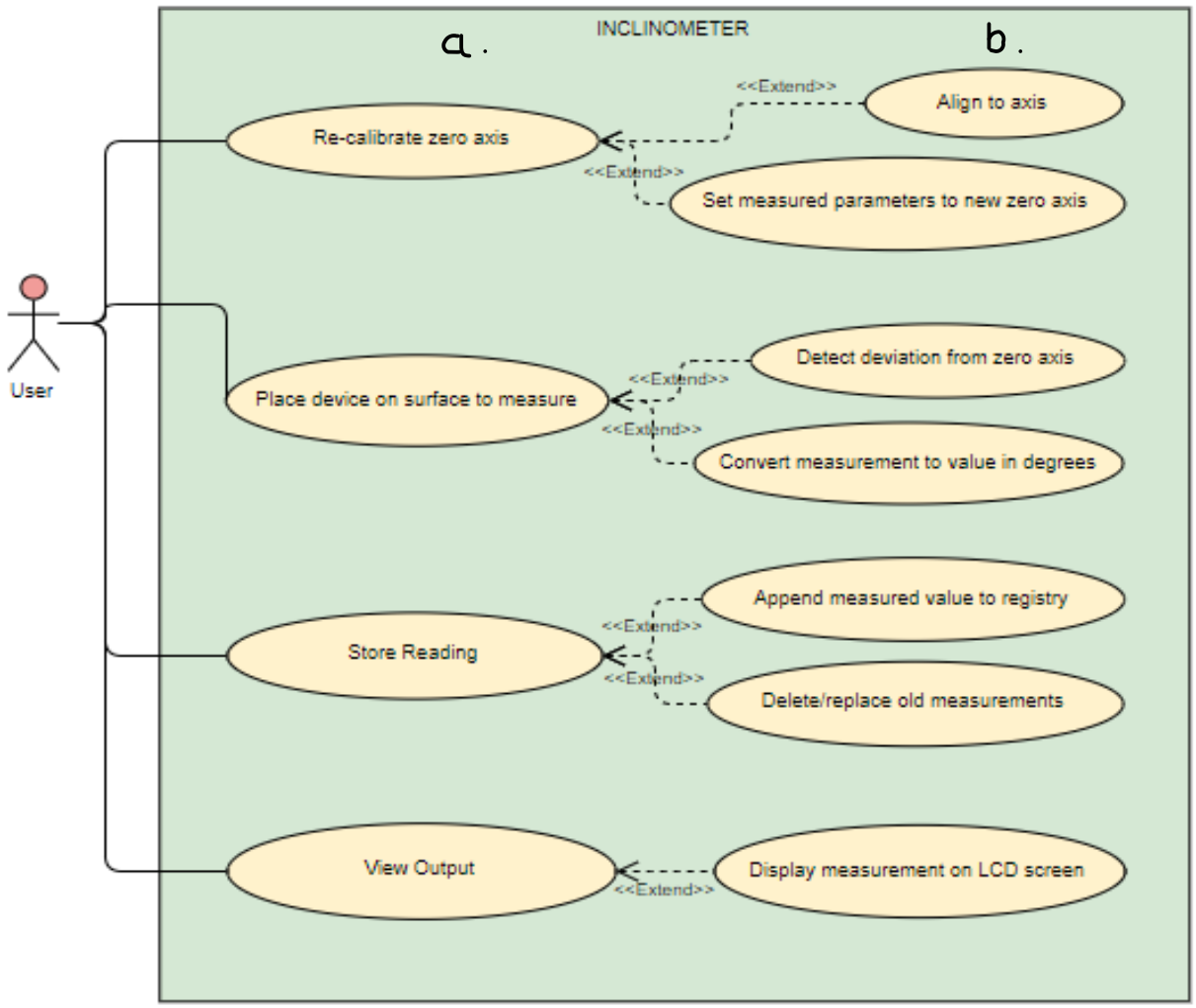
1. By analyzing the requirements, formulate the design problem to satisfy the user's needs by deriving a set of 10 functional requirements.

i. The device should be able to measure a difference in angle/angular displacement about a predefined axis.
ii. Must have a digital display to provide feedback to the user.
iii. The battery power should last sufficiently long enough. This is because of the purpose of the device which can sometimes be used in areas of no power connections.
iv. The device must be able to recalibrate. Having a device which resets the axis of rotation (reference axis) helps simplify measurements.
v. Must have some form of memory storage. This helps to record previous measurements and refer back when required.
vi. The device must be able to measure on an uneven surface. It's not always that a measuring surface would be flat and hence the device should be able to measure on an uneven platform
vii. Must be durable and have a high shock survival rate. There are high chances of these devices to fall from a platform and hence it should not break easily.
viii. The physical dimensions should provide good support while conducting measurements.
ix. The device should be water resistant.
x. The output should be provided before a new data set is measured.

2. Using an UML case diagram, show:

a. how a user will interact with the device when trying to measure an angle, and

b. the sub-tasks the device must complete in order to achieve this task



3. List 5 possible constraints and challenges in relation to the components involved in the proposed system and how would you achieve the requirements.

i. Power consumption. The device should consume less power and hence a use of rechargeable batteries would be convenient. Also, while designing the device, we must use low power rated components and efficient circuitry

ii. Accuracy of the accelerometer and tolerance of passive components. We must have use high accuracy components as per how the budget allows which would provide high resolution and high signal-to-noise ratio for the 8-bit Analogue to Digital Converter (ADC) used. We must also use low tolerance resistors and capacitors.

iii. Uneven surfaces cause external noise/error in the signal due to added vibrations and shock. To overcome this, we need to introduce a gyroscope in the design which would provide more accurate measurements.

iv. Device wear and tear. Measuring devices are often subjected to wear and tear and to curb this issue, we need to make a durable device which has external casing providing shock and water resistances. We could use rubber on the casing to help absorb shock and vibrations.

v. Overall cost of the device. We need to make a trade off between accuracy of the component versus making the device readily available to public. In order to reduce cost, we need to limit the number of components used but not compromising the overall functioning of the device.

4. List the set of final specifications of your design and the functional requirement(s) which they are derived from.

i. Angular displacement: 360^{o} range with 0.5^{o} accuracy
ii. Display: LCD screen; should output measurements up to 4 significant figures and the contrast ratio should be within ±50% initial value. 8-bit resolution
iii. Battery: 5600mAh Li-ion battery pack
iv. Recalibration: Upon user request. Have a reset button.
v. Memory: Store up to 10 previous measurements.
vi. Uneven surface: Linear displacement of up to 1cm from the flat surface.
vii. Durability: withstand temperature ranges from -10^{o}C to 60^{o}C. Shock survival < 500g
viii. Physical dimension: 1-meter length, 5cm width, 2cm height. Weight of 2kg
ix. Water resistant: Up to 5 atm = 50m of depth
x. Output duration: within 0.1ms delay of a change in angle

5. Design an acceptance test protocol (ATP) to test your design. Include at least 5 use test cases including which requirements must be met for the test to pass/fail.

TEST CASE ID	**TEST SCENARIO**	**TEST STEPS**	**EXPECTED RESULT:**	**PASS/FAIL**
TC01	Check for temperature sensitivity in an environmental chamber	1. Put the device in the chamber 2. Run the test to determine the temperature range 3. Record data	Ranges from -10^{o}C to 60^{o}C	Pass

TC02	Check for water resistance using a dry method pressure test	1. Seal the device so that no air leaks inside 2. Set the pressure of the dry method equipment to 5 atm 3. Put the inclinometer on a tray of the equipment and wait for the indicator probe to touch the device 4. The probe should remain stationary. 5. If probe moves, then that's the maximum pressure the device can handle	The probe should not move reaching before 5 atmospheres	Pass
TC03	Check memory storage by randomly inputting data	1. Provide the inclinometer with a bunch of input measurements 2. Check memory storage to see how many measurements have been saved.	Stores up to 10 previous measurements	Pass
TC04	Check for battery capacity using a programmable DC Electronic load tester	1. Connect the battery to the load tester. 2. Select operating levels of current and voltage 3. Calculate the charge-discharge cycle	Energy calculated should be 5600mAh	Pass
TC05	Using Mechanical shock testing to check the device's response	1. Place the inclinometer on the platform of the testing equipment 2. Subject the test device to sudden and vigorous amounts of accelerations and decelerations. 3. Measure the test device's response	The device should survive responses of approximately <500g	Pass

TC06	Measuring physical dimensions of the device using digital calipers and weighing scale	1. Place the device on a weighing scale to measure its mass 2. Then measure its length, width and height using a digital caliper	Length = 1m Width = 5cm Height = 2cm Weight = 2kg	Pass

Below is the Acceptance Test Protocol (ATP) for Builders Warehouse's digital inclinometer. The acceptance test should verify that the device works as required and validates that the correct functionality has been delivered. The details of the ATP are developed according to the requirements specifications.

Functional Requirement	Design Specification	Test Cases
The device must be durable and have a high shock survival rate	Must withstand temperature ranges from -10^{o}C to 60^{o}C. Shock survival < 500g	TC01, TC05
The device should be water resistant	The device must be water resistant up to 5 atm = 50m of depth	TC02
Must have some form of memory storage	Can store up to 10 previous measurements	TC03
The battery power should last sufficiently long enough	Must be a Li-ion battery pack with an energy rating of 5600mAh	TC04
The physical dimensions should provide good support while conducting measurements	The device should be 1-meter in length, 5cm in width and 2cm in height and should weigh 2kg	TC06