Project Proposal

### **Team ID**: 16

### **Project Title**: Smart Railway Track Condition Monitoring with ML Integration

# Introduction:

This project aims to implement a solution for early detection of faults in railway tracks through the use of sensors such as vibration and temperature sensors and ML and inform the respective authorities to ensure proper fixing of railway tracks before, they lead to great infrastructure damage and a threat to hundreds of lives. This project aims to create a model of train tracks of various conditions and collect data (or use any available real-world data) to train a ML model as one would in the field. Then create an implementation which will detect defects in the model train tracks using an accelerometer, then analyze the collected real-time reading through the use of a trained ML model on the cloud and classify the reading as safe or dangerous and inform the appropriate authorities to take the necessary proactive measure such as fixing or replacing the segment of track.

# Hardware Requirements:

### Required Sensors:

* Accelerometers:
  + **Quantity**: 2 to 4
  + **Series**: MPU-6050 (Accelerometers are available in the Lab, hence we will use what is available)
  + **Contributions**: This sensor will allow us to collect vibration readings of the model track and then analyze to see whether the readings are of healthy or damaged tracks.
* Temperature Sensors:
  + **Quantity**: 1
  + **Series**: Will use what is available in the labs.
  + **Contributions**: The readings from the temperature sensor will determine how the threshold for determining the difference between a healthy and damaged track is, and the model will be created with temperature as a parameter.

### Required Actuators:

* Piezo electric Buzzer:
  + **Quantity**: 1
  + **Contributions**: The purpose of this is to buzz when the ML model on the cloud determines a vibration from the tract identifies that the track is faulty and needs repair. This will alert the necessary authorities of it immediately.
* Servo Motor:
  + **Quantity**: 1
  + **Contributions**: Can be used to set up some type of obstacle of sign to make inform on lookers of a problem or if the problem is severe enough a sign large enough to inform oncoming trains about it.

### Required MCUs and Modules:

* ESP-32:
  + **Quantity**: 2
  + **Contributions**:
    - One will be wired to the temperature sensor and accelerometer to collect the data, process it, and send it to the python ML model hosted on the cloud.
    - The other ESP will be listening for the vibration result and will be connected to the buzzer to inform the authorities about any problems with the tracks.
* Cellular Module:
  + **Quantity**: 1
  + **Series**: SIM800L
  + **Contribution**: As cellular is widespread all across India, it is a better and cheap way to communicate through a SIM card than any other method which usually cost quite a lot of money. This makes this module very affordable for anyone, and even though it uses 2G for communication it is still quite affordable.
* Battery/Power Supply:
  + **Contribution**: To ensure every sensor and MCU is powered reliably in the prototype.

### Model Hardware:

* Wooden planks:
  + **Quantity**: 4
  + **Contribution**: Each plank will provide a stable base for our steel rods (that model tracks) to sit stably on. This will ensure the stability of our tracks when disturbed with vibrations
* Steel Rods:
  + **Quantity**: 4
    - Solid steel rod to simulate a healthy track
    - Solid steel rod with holes to simulate a regular track with defects
    - Hollow steel rod to simulate a healthy track with internal defects or under expansion due to increase in temperature
    - Hollow steel rod with holes to simulate a track with internal defects or under expansion due to increase in temperature with defects.
  + **Contribution**: These will serve as model tracks for us to present our IoT implementation during the presentation phase, and also help us with data collection if necessary.
* Vibration Motor:
  + **Quantity**: 1
  + **Series**: Will be using an electric toothbrush or out phones
  + **Contribution**: This motor will help us simulate the vibrations a track will go through when a train goes on it, so we can measure vibration s of different types of tracks.

# Data Collection plan:

### Two plans:

* We have found a dataset online that has collected accelerometer data of railway tracks in relation to temperature and humidity. If our prototype with the accelerometer can read give us similar readings to that of the dataset, we plan on using the dataset to model our ML model on. The dataset can be found at: <https://researchdata.up.ac.za/articles/dataset/The_vibration_sensor_on_railway_lines/24973911>
* If the data collected from our accelerometer and prototype does not reflect the dataset we have found. We plan to use our prototype to collect accelerometer data of 15 samples for each type of track for 10 days for a total of 500+ samples of track data, which will be then used to train the ML model to be able to classify any future reading into safe/unsafe. This would reflect the data collection that would have to be carried out in the real-world before any ML model can be trained or before the vibration readings would be properly classified. This would be replicable in real life because if we were to implement something similar in the real world, we will have to find various different types of tracks, under different types of temperature conditions, and tracks that have defects. Then this data will have to be labeled and then trained to gain insight. After training the model on the data, the actual vibrations can be analyzed.
* We plan on using a Random Forest Model to analyze our collected data, as it does the best with smaller datasets and is able to give accurate predictions after being trained.

### Possible Inferences:

* Through this data collection and analysis through an ML model, we plan to be able to find the range of safe vibration values for a train track (in our case the model train track) so that any further reading will be classified properly.
* This analysis will also give us a trend to add more data and also find the error margin or how reliable vibration reading along with temperature sensor readings are for detecting faulty railway tracks.

# Conclusion:

This project aims to create a prototype that will be able to classify safe track vibration readings and unsafe vibration readings to give information about the safety of the track. This will be done by taking accelerometer readings and temperature readings from four different types of tracks, which will then be sent to the cloud to be categorized, then to another designated place (an ESP) to take action based on the severity of the reading. When deployed on the field, this architecture will allow for proper action to be taken by the authorities when they get notified of a heavily damaged track to ensure no further causalities are faced in the future.