Traffic Relief

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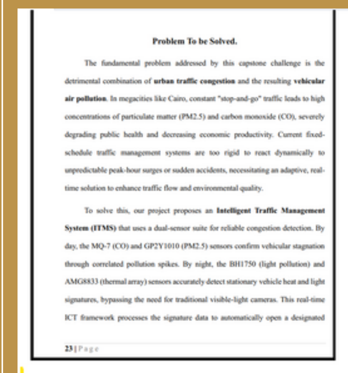
STEM High School

for boys – 6th of October

Grade 12 2025/2026

1st Semester

10343

<table>
<tr><th>Weeks</th><th>Tasks</th><th>Proof</th></tr>
<tr><td>Week One</td><td>Working on the capstone project challenge and writing the grand challenges "Deal with population growth and its consequences"</td><td>   </td></tr>
<tr><td>Week Two</td><td>Searching about the challenge and defining the specific problem to be solved and writing this section in the portfolio</td><td>

Problem To be Solved.

The fundamental problem addressed by this capstone challenge is the detrimental combination of **urban traffic congestion** and the resulting **vehicular air pollution**. In megacities like Cairo, constant "stop-and-go" traffic leads to high concentrations of particulate matter (PM2.5) and carbon monoxide (CO), severely degrading public health and decreasing economic productivity. Current fixed-schedule traffic management systems are too rigid to react dynamically to unpredictable peak-hour surges or sudden accidents, necessitating an adaptive, real-time solution to enhance traffic flow and environmental quality.

To solve this, our project proposes an **Intelligent Traffic Management System (ITMS)** that uses a dual-sensor suite for reliable congestion detection. By day, the MQ-7 (CO) and GP2Y1010 (PM2.5) sensors confirm vehicular stagnation through correlated pollution spikes. By night, the BH1750 (light pollution) and AMG8833 (thermal array) sensors accurately detect stationary vehicle heat and light signatures, bypassing the need for traditional visible-light cameras. This real-time ICT framework processes the signature data to automatically open a designated

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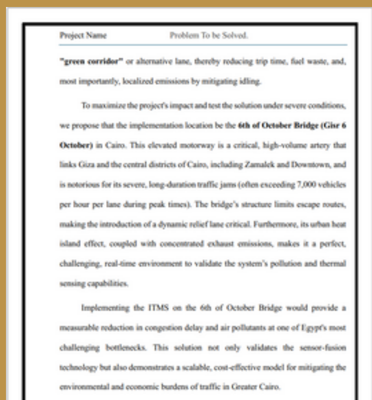
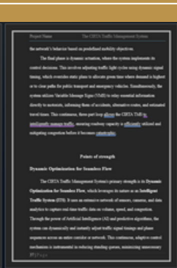
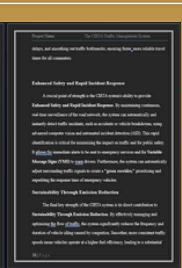
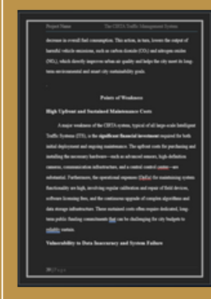
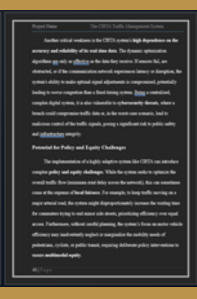


Project Name Problem To be Solved.

"green corridor" or alternative lane, thereby reducing trip time, fuel waste, and, most importantly, localized emissions by mitigating idling.

To maximize the project's impact and test the solution under severe conditions, we propose that the implementation location be the **6th of October Bridge (Gisr 6 October)** in Cairo. This elevated motorway is a critical, high-volume artery that links Giza and the central districts of Cairo, including Zamalek and Downtown, and is notorious for its severe, long-duration traffic jams (often exceeding 7,000 vehicles per hour per lane during peak times). The bridge's structure limits escape routes, making the introduction of a dynamic relief lane critical. Furthermore, its urban heat island effect, coupled with concentrated exhaust emissions, makes it a perfect, challenging, real-time environment to validate the system's pollution and thermal sensing capabilities.

Implementing the ITMS on the 6th of October Bridge would provide a measurable reduction in congestion delay and air pollutants at one of Egypt's most challenging bottlenecks. This solution not only validates the sensor-fusion technology but also demonstrates a scalable, cost-effective model for mitigating the environmental and economic burdens of traffic in Greater Cairo.</td></tr>
<tr><td>Week Three</td><td>Searching for prior real-life solutions to benefit from them and writing about “The CIRTA Traffic Management System”</td><td>     </td></tr>
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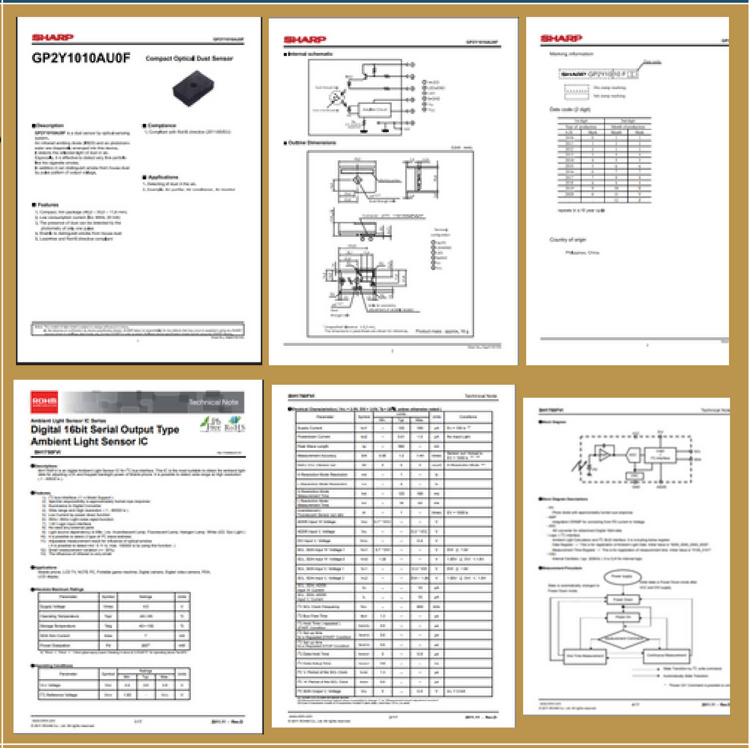
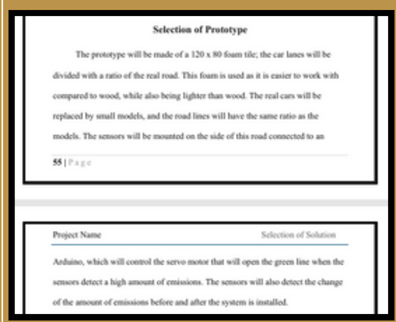
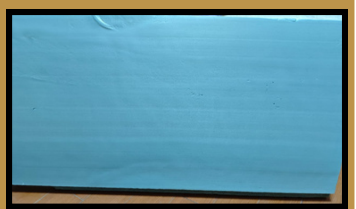
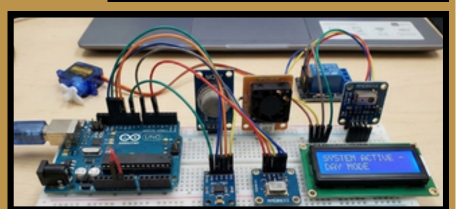
Weeks	Tasks	Proof
Week Four	**Reviewing the datasheet for sensors to ensure their suitability for the project**	
Week Five	**Searching for privious solutions for the same challenge and the prior solution was written as shown**	
Week Six	**Buying materials (all sensors and the foam to simulate the road), and writing selection of prototype**	 Selection of Prototype The prototype will be made of a 120 x 80 foam tile; the car lanes will be divided with a ratio of the real road. This foam is used as it is easier to work with compared to wood, while also being lighter than wood. The real cars will be replaced by small models, and the road lines will have the same ratio as the models. The sensors will be mounted on the side of this road connected to an 55 | Page Project Name Selection of Solution Arduino, which will control the servo motor that will open the green line when the sensors detect a high amount of emissions. The sensors will also detect the change of the amount of emissions before and after the system is installed.  

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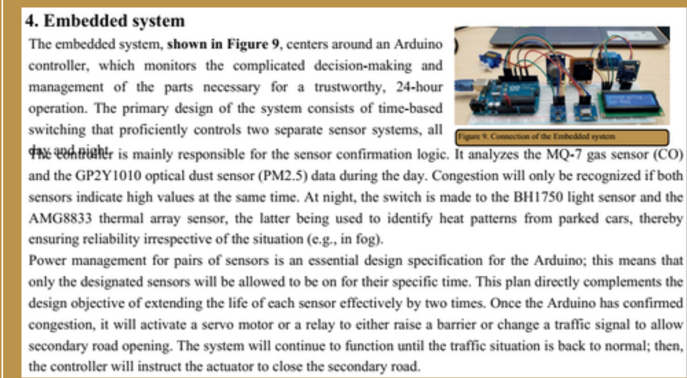
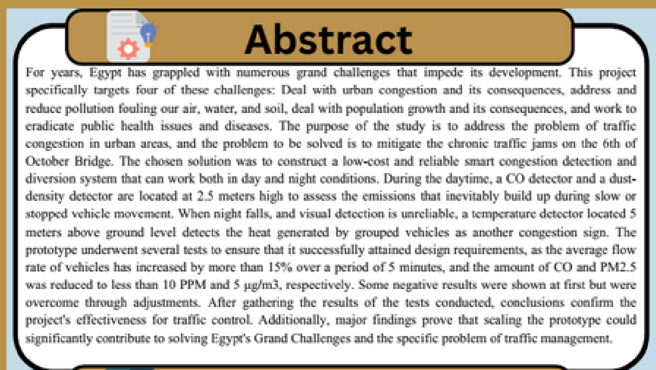
<tr><th>Weeks</th><th>Tasks</th><th>Proof</th></tr>
<tr><td>Week Seven</td><td>Writing the Methods and Test Plan sections in the poster and portfolio</td><td>
Methods
1. The 3D design was done. As shown in Figure 2.
2. A large, flat piece of Styrofoam was used as the main base to provide a stable platform for mounting all components and simulating a roadway environment. As shown in Figure 3.
3. The styrofoam was covered with colored paper to simulate the road shape. As shown in Figure 4.
4. The sides of the road were mounted using wood sticks. As shown in Figure 5.
5. The MQ-7 gas sensor (CO) and the GP2Y1010 optical dust sensor (PM2.5) were placed near the roadway on a lighting pole on the roadside.
6. The Arduino controller was securely attached to the Styrofoam base using glue, tape, or small supports, serving as the central hub for the entire system.
7. The servomotor was connected to the Arduino controller and mounted on the Styrofoam base right next to the barrier arm's pivot point, representing the gate to the "green road."
8. All sensors, the servo motor, and power components were connected to the appropriate digital, analog, and power pins on the Arduino controller using jumper wires, following the circuit schematic for dual-mode operation.As shown in Figure 6.
Testplan
To demonstrate the project's applicability, the following tests were conducted. Each step of the test plan aims to test a specific design requirement.
1. A simulation was done to approximate the results on the 6th October Bridge.
2. Virtual sensors were put in the model to measure the flow rate and pollution levels before and after the opening of the secondary road.
3. The barrier mechanism was included in the simulation to show how the system redistributes the traffic. The timer was checked to ensure the barrier opens or closes within 3 seconds for safety.
Figure 2. 3D design for the project
Figure 3. Styrofoam as a platform
Figure 4. Mounting colored paper
Figure 5. Mounting sides of the road
Figure 6. Mounting Arduino and sensors</td></tr>
<tr><td>Week Eight</td><td>Writing an analysis point explaining the embedded system in our prototype</td><td>
4. Embedded system
The embedded system, shown in Figure 9, centers around an Arduino controller, which monitors the complicated decision-making and management of the parts necessary for a trustworthy, 24-hour operation. The primary design of the system consists of time-based switching that proficiently controls two separate sensor systems, all day and night.
The controller is mainly responsible for the sensor confirmation logic. It analyzes the MQ-7 gas sensor (CO) and the GP2Y1010 optical dust sensor (PM2.5) data during the day. Congestion will only be recognized if both sensors indicate high values at the same time. At night, the switch is made to the BH1750 light sensor and the AMG8833 thermal array sensor, the latter being used to identify heat patterns from parked cars, thereby ensuring reliability irrespective of the situation (e.g., in fog).
Power management for pairs of sensors is an essential design specification for the Arduino; this means that only the designated sensors will be allowed to be on for their specific time. This plan directly complements the design objective of extending the life of each sensor effectively by two times. Once the Arduino has confirmed congestion, it will activate a servo motor or a relay to either raise a barrier or change a traffic signal to allow secondary road opening. The system will continue to function until the traffic situation is back to normal; then, the controller will instruct the actuator to close the secondary road.
Figure 9. Connection of the Embedded system</td></tr>
<tr><td>Week Nine</td><td>Writing the "Abstract" section in the Poster</td><td>
Abstract
For years, Egypt has grappled with numerous grand challenges that impede its development. This project specifically targets four of these challenges: Deal with urban congestion and its consequences, address and reduce pollution fouling our air, water, and soil, deal with population growth and its consequences, and work to eradicate public health issues and diseases. The purpose of the study is to address the problem of traffic congestion in urban areas, and the problem to be solved is to mitigate the chronic traffic jams on the 6th of October Bridge. The chosen solution was to construct a low-cost and reliable smart congestion detection and diversion system that can work both in day and night conditions. During the daytime, a CO detector and a dust-density detector are located at 2.5 meters high to assess the emissions that inevitably build up during slow or stopped vehicle movement. When night falls, and visual detection is unreliable, a temperature detector located 5 meters above ground level detects the heat generated by grouped vehicles as another congestion sign. The prototype underwent several tests to ensure that it successfully attained design requirements, as the average flow rate of vehicles has increased by more than 15% over a period of 5 minutes, and the amount of CO and PM2.5 was reduced to less than 10 PPM and 5 µg/m3, respectively. Some negative results were shown at first but were overcome through adjustments. After gathering the results of the tests conducted, conclusions confirm the project's effectiveness for traffic control. Additionally, major findings prove that scaling the prototype could significantly contribute to solving Egypt's Grand Challenges and the specific problem of traffic management.</td></tr>
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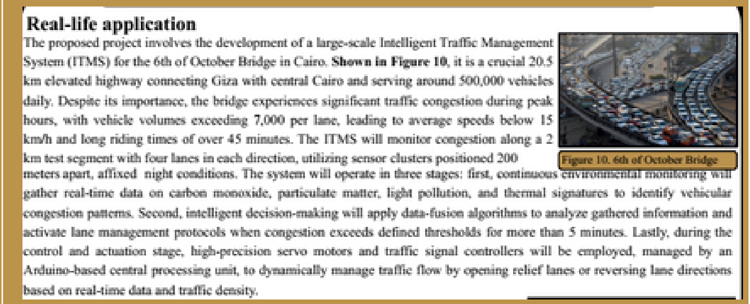
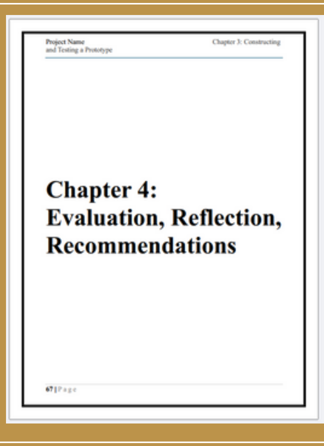
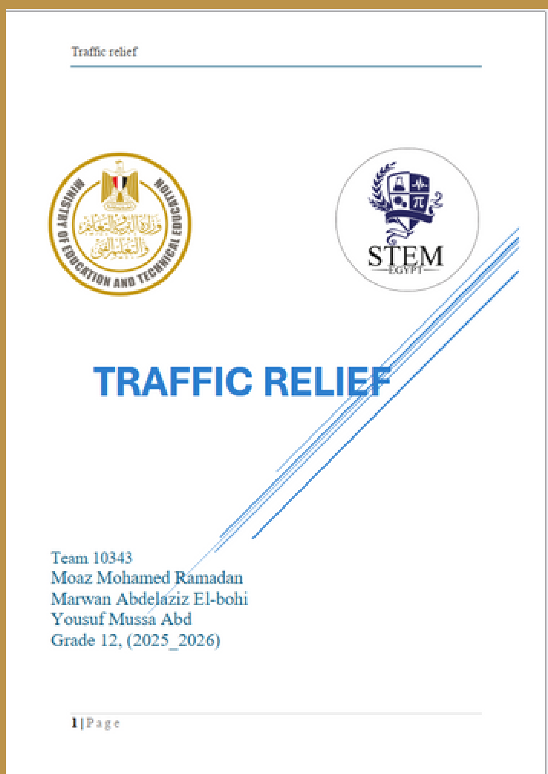
Weeks	Tasks	Proof
Week Ten	**Writing the first Recommendation point about the real-life application**	 **Real-life application** The proposed project involves the development of a large-scale Intelligent Traffic Management System (ITMS) for the 6th of October Bridge in Cairo. **Shown in Figure 10**, it is a crucial 20.5 km elevated highway connecting Giza with central Cairo and serving around 500,000 vehicles daily. Despite its importance, the bridge experiences significant traffic congestion during peak hours, with vehicle volumes exceeding 7,000 per lane, leading to average speeds below 15 km/h and long riding times of over 45 minutes. The ITMS will monitor congestion along a 2 km test segment with four lanes in each direction, utilizing sensor clusters positioned 200 meters apart, affixed night conditions. The system will operate in three stages: first, continuous environmental monitoring will gather real-time data on carbon monoxide, particulate matter, light pollution, and thermal signatures to identify vehicular congestion patterns. Second, intelligent decision-making will apply data-fusion algorithms to analyze gathered information and activate lane management protocols when congestion exceeds defined thresholds for more than 5 minutes. Lastly, during the control and actuation stage, high-precision servo motors and traffic signal controllers will be employed, managed by an Arduino-based central processing unit, to dynamically manage traffic flow by opening relief lanes or reversing lane directions based on real-time data and traffic density. Figure 10. 6th of October Bridge
Week Eleven	**Writing Chapter four of the portfolio**	 **Chapter 4: Evaluation, Reflection, Recommendations**
Week Twelve	**All parts were collected in the portfolio and it was submitted to the capstone leader**	 Traffic relief **TRAFFIC RELIEF** Team 10343 Moaz Mohamed Ramadan Marwan Abdelaziz El-bohi Yousuf Mussa Abd Grade 12, (2025_2026) 1 | Page