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TORMINATOR (ROBOTIC ARM)

REPORT

1 GOAL

- The Basic goal of the project is to study the behavior of a 6-DOF robotic arm and to develop a high precision farming Bot. Being teleoperated, the robot is designed to carry out farm harvesting such as picking ripe tomatoes.

- The working of the robot has been designed in such a way that it allows us to detect and locate the precise 3D coordinates of the ripened tomato from the images of the tomato plants, even sitting at a distance.

- This robotic arm is mounted on a semi-autonomous rover that moves over rows of tomato plants to harvest the complete tomato field. This mechanism is aimed at closely mimicking the human method of picking, but at a much higher productivity and efficiency level of manual picking.

2 TECHNOLOGIES USED

Fusion 360 is used to design 6 degrees of freedom robotic arm with a whole base and wheels. Fusion 360 is a complete parametric CAD tool developed by Autodesk. It is considered by many as a combination with the best tools of cutting-edge programs like Rhino, Inventor, SolidWorks, Vault, and AutoCAD.

Unity is used to show the working simulation of a robotic arm in virtual mode for the job of collection of ripe oranges which can be further implemented in real-life farms in India. In unity, we designed the background, shaped the movement of each joint to achieve 6 DOF, and scripted the model so that we can simulate the robotic arm using a simple joystick or keyboard.

3 ROBOTIC ARM

- A very strong and efficient robotic arm with six degrees of freedom (base, shoulder, elbow, wrist, two degrees of freedom in the end effector) has been incorporated into our bot.
- The essential part of the robotic arm is a programmable microcontroller-based brick capable of driving five servos & the design of a dc motor to form an anthropomorphic structure.

Fig1 : robotic arm

3.1 MECHANICAL STRUCTURE

The Robotic arm which is made of Aluminium is meant for lifting loads, removing obstacles, and collecting samples. This is framed above a wooden base provided with an antenna for controlling. The basic work is to pick up the object that comes in its clutch range and put it in the container provided in the vehicle on which it is situated. Reasons for design are listed below:
1. We used Aluminium because it is light in weight which makes it convenient for portability and also it has flexibility. It makes the arm lightweight without compromising its strength. We can get maximum.

2. We used Bearing at the bottom of the robotic arm to provide 360-degree rotation to our robot and to have minimal resistance when the upper arm will rotate.

3. For the base of the robot we have chosen a cylindrical base to provide stability over the flat surface of an automated vehicle.

3.2 MOTORS INFO

In this project, we will be using 7 servo motors and 1 DC motor for the movement of the robotic arm. 3 high torque motors will be used for the movement of the arm, 3 micro servos will be used, one for each finger of the end effector, and 3 micro servos will be used, one for each finger of the end effector

We will use 3 micro servos to move the fingers, one servo for each, for better grip and more flexibility. We will use 1 DC motor for the rotation of the wrist because we will be needed high torque motor to move the fingers due to the weight of the fingers and the fruit, held by the fingers. Also, in the body of the arm, we will use high torque servos as it will require high torque to move the above parts. Circuital assembly of the motors with Arduino board is shown below -

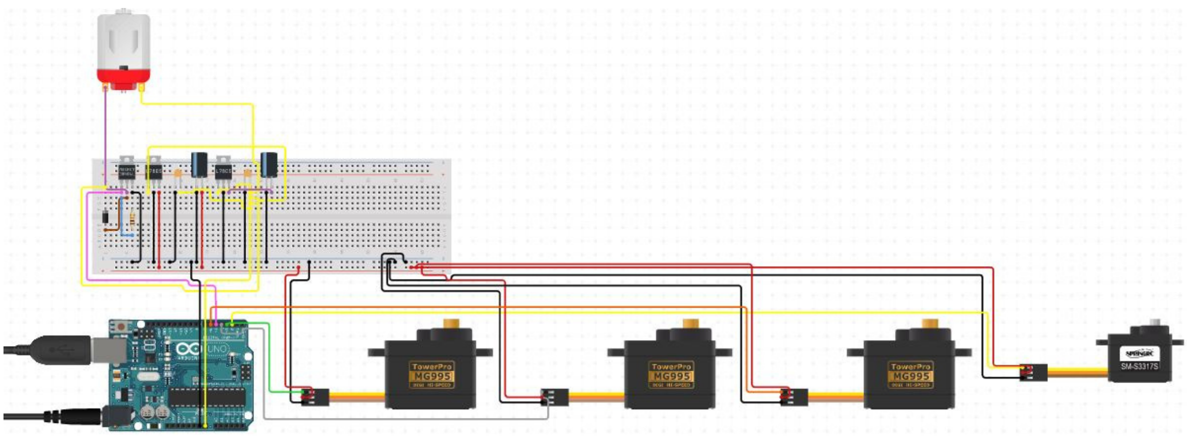


Fig2 : Arduino circuit for arm

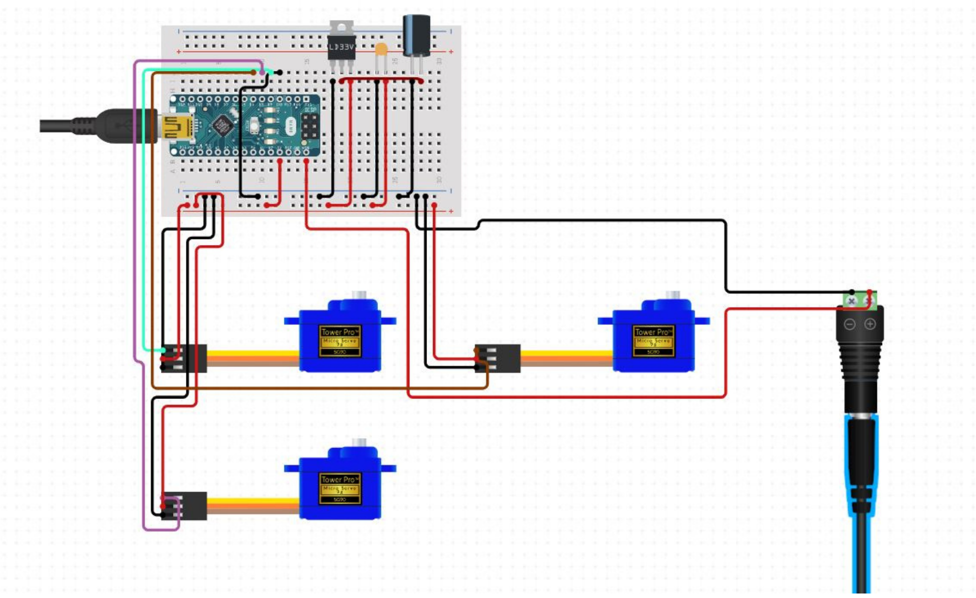


Fig3 : Arduino circuit for gripper

The servos that is employed to control the gripper portion will help in controlling 3 claws of gripper using a special mechanism.

3.3 WORKING OF ROBOTIC ARM

- Inverse kinematics is a mathematical process used to calculate the joint positions that are needed to place a robot's end-effector at a specific position and orientation (also known as its "pose"). A reliable inverse kinematic solution is necessary for programming a robot to perform tasks.

- It's important to be clear about the differences between the inverse kinematics and the robot's forward kinematics.

- Forward kinematics determines where the end effector will be if the joints are set to a specific position. There is only ever one solution to the forward kinematic equation. When the joints are set to a specific position, the end effector will always end up in the same place.

- With inverse kinematics, there are often multiple different solutions and multiple approaches to calculating the inverse kinematic solution.

- The inverse kinematics are required to define the parameters of the actuators if the position and orientation of the tooltip are given and the inverse kinematic model is used in position control of the robot.

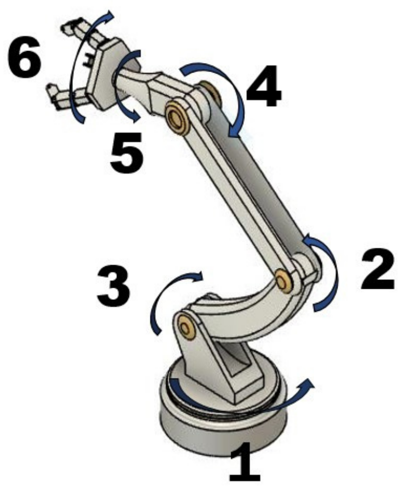


Fig4 : 6 DOF of Robotic arm

3.4 End Effector

3.4.1 Working and structure-

- The designed end-effector is a three-fingered gripper comprising fingers, a spring plate, and finger bending mechanisms.
- Each finger has four sections and a total length of 138 mm. The lengths of the four sections are 36, 32, 37, and 33 mm. All the joints between the sections are flexible and provide cushioning when grabbing the tomatoes.
- Soft foam rubber was placed on each finger section to prevent damage to the fruit surface. The three fingers were divided into two sets, installed on the left and right open-close plates, and controlled using the sideways open-close chuck at the tip of the robotic arm. When the open-close plates are open, the opening at the tip of the end effector is oval-shaped. Because the open-close plates move sideways, it forms a round opening that is 60 mm in diameter. When the solenoids pull the spring plates on the inside of the fingers, the fingers bend, reducing the opening of the tip of the end-effector to a 40-mm circle. This secures the tomato within the end effector.

3.4.2 Bending Mechanism-

The figure shows the finger bending mechanism, which includes a spring plate, wire, and solenoid. One spring plate is inserted into each of the three fingers, with a wire connecting the tip to the solenoid. When the solenoid is magnetized, it pulls the steel wire on the inside of the finger, drawing the tip in and forcing the spring plate to bend. This causes the three sections of the fingers to curl similarly to human fingers when gripping something. Limit switches that control the finger curving extent were inserted into the base of the fingers. When the three fingers curl together, the opening of the tip of the end-effector shrinks, enhancing its grip on the fruit.

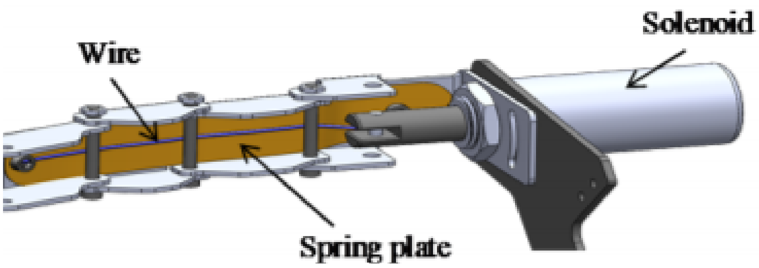


Fig5: Finger of end effector

4 WHEELS

Wheels shall be needed for exploration, transportation of the whole robotic arm system from one place to another on rough terrains to pick oranges from the orange farms. The design of the wheel should be such that it overcomes the unique environmental constraints and meets the transportation requirements for the job.

Fig6: wheel

4.1 Wheel Rim

We shall be using alloy wheels instead of steel or chrome rim for our system cause:-

- Alloy rims are made from aluminum or magnesium or both. They have less weight when compared to steel rims. This less weight is a good thing for the driver; you get faster acceleration and minimum stop motion.
- Another good side of alloy rims is there will be less strain on the suspension of your system. Alloy rims add much to the good look of a system.

Fig7: wheel rim(alloy)

4.2 Dimensions

Inner Diameter-296mm
Outer Diameter-314mm
Weight- 1.3kg

Width of Rim-53mm
Width of Tyre-65mm

4.3 Outer surface of wheel

Fig8: Tyre of wheel

- The outer surface of tyre is designed with a periodic wavy spikes pattern over the whole surface with the intent to increase friction and grip with the plains and help in smooth travel of the bot.
- This pattern avoids any growth tracks and it has been shown real efficient in tests.

4.4 Torque and Motor info

- For the motion of the robotic arm, the required torque on each wheel is approximately 1.3 nm .
- That's why we are using 4 12v dc gear motor for the wheels, which offers a range of 0.29 Nm to 1.47 Nm.
- The length, width, and height Of the motor are 10 cm each.it also provides a speed of 1.1 rpm to 1000 rpm to the wheel so that we can move our robot with a desirable speed.

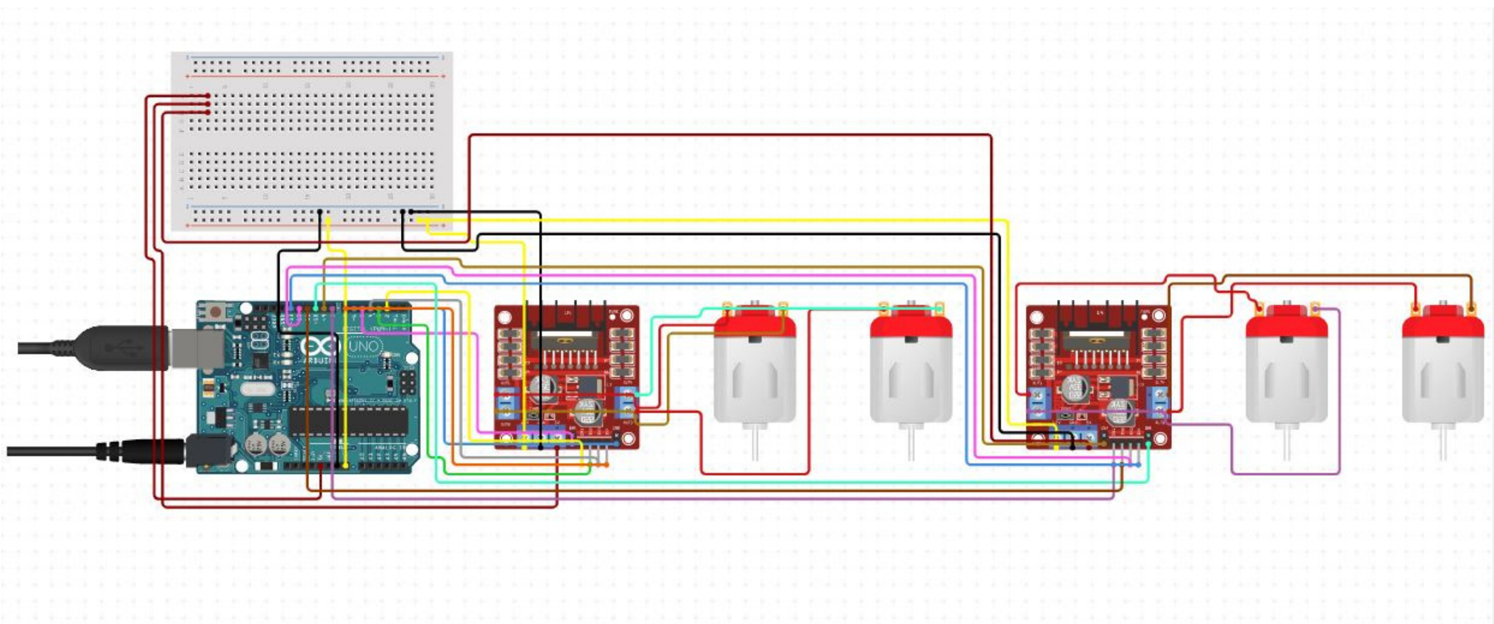


Fig9 : Arduino circuit for wheels

5 POWER

- We have used 4 Lithium-ion Batteries of size 106X34X23 mm each consisting of 4 cells of voltage 3.3V occupying the whole back of the wooden base.
- Each battery is of size 2.2Ah(Amp hour) providing an output voltage of 11.2~12V. The batteries are chosen to make the whole system operable for 2 hrs per single-use and it takes approx 2.5 hours to recharge each battery with 10A current.
- This makes it reliant as 2 hours is enough time for collecting oranges from farms during the day.

Fig10 : Lipo Battery

Advantages over Lithium ion battery over Nickel-Cadmium or Lead cell

- Longer Service Life: Our LiFePO4 battery provides 2500 - 7000 cycles & a 10 years lifetime compared to 200 - 500 cycles & a 3 years lifetime in typical Lead Acid chemistry.

- Efficient Power: Our LiFePO4 battery's flat discharge curve holds above 12V for up to 95% of its capacity usage providing astronomical boosts in run-time compared to only 50% in Lead Acid.

- Impeccably Lightweight: Our LiFePO4 battery is only a 1/3 of the weight of Lead Acid which makes it the disputable choice for RVs, Marine and Off-Grid Applications when towing or mobility is in the consideration.

- Complete Protection: The lithium battery's unique built-in Battery Management System (BMS) protects it from overcharge, deep discharge, overloading, overheating and short circuit, and excessive low self-discharge rate ensuring up to 1 year maintenance-free storage. Built-in low-temp cut off prevents charging under 23 °F (-5 °C).

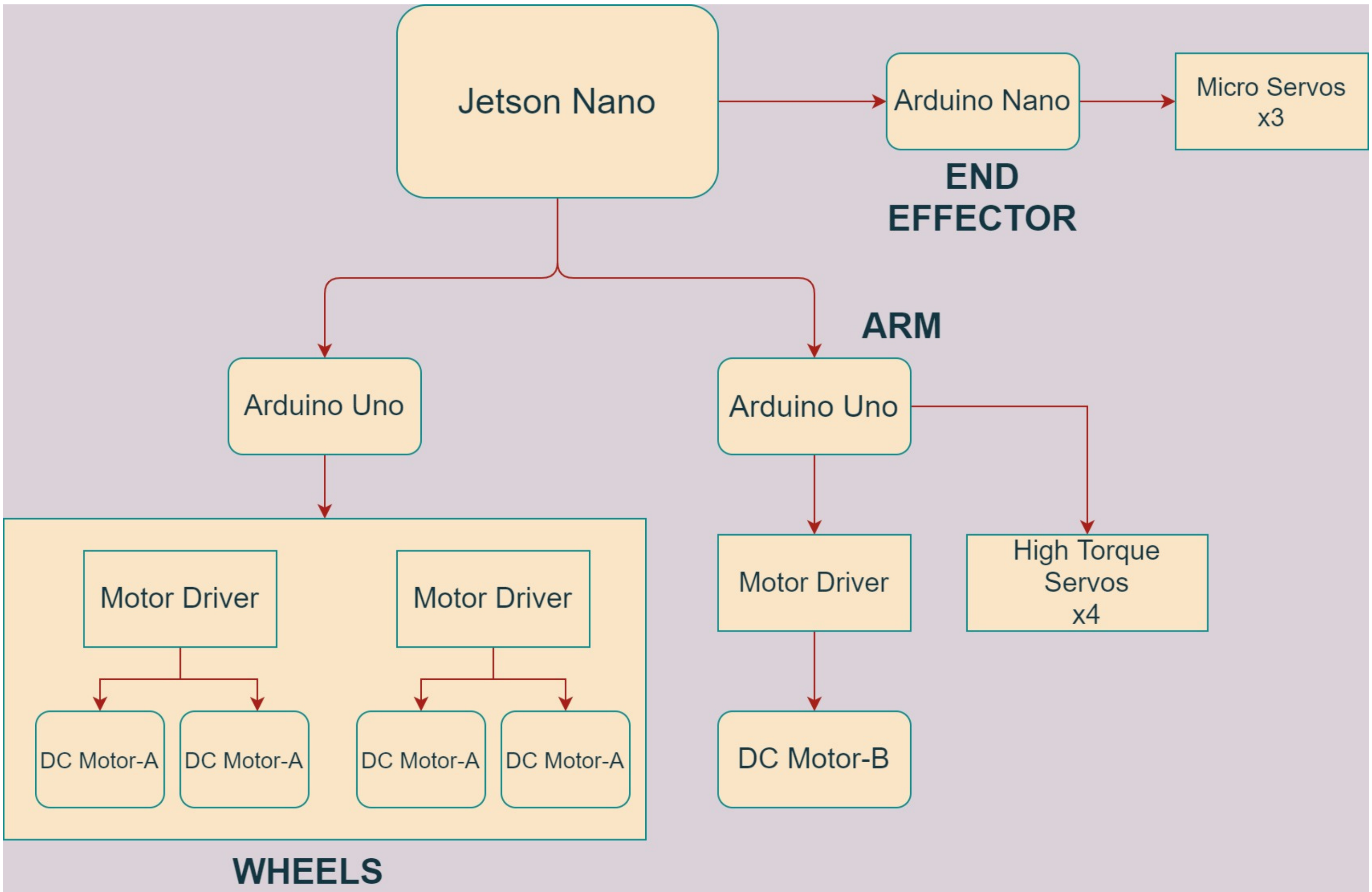
6 COMMUNICATION

Fig11: 900 MHZ module + antena

- We shall be using a 900MHz radio band for interaction between driver and robotic arm system!!
- The robotic arm is equipped with a whip antenna 5dbi and a pico station module and the driver will control the wheels and rover with a game controller/two joysticks through an omnidirectional antenna equipped with a pico station module to communicate with the robotic arm.
- This system works within a range of 1.5km (LOS) and 1km (Non-LOS) feasible for large farms in India.
- The reason for choosing 900MHz over other RF frequencies is the better range and less blockage by any obstacle coming in between antennas. It also has less atmospheric attenuation and serves well for all motor controls.

7 CONTROLLING

- For controlling the arm, we will be using Jetson nano as the main processor since it has a better CPU than Raspberry Pi.
- We will control the arm from a distance. Jetson nano will receive the signal for the desired work and accordingly it will command the Arduino. Afterward, Arduino will control the movement of the arm and the wheels. In this project, we are using two Arduino Uno instead of mega due to the fewer number of unused posts and cost advantages.
- In addition to two Unos, we are using one Arduino Nano specifically for controlling of three micro servos of gripper
- One Uno for the wheels will help the arm to reach the desired location and the other Arduino will control the arm movement. Since the main arm and the wheels will perform different tasks, it's better to keep them controlled separately by different Arduino.



8 FUTURE SCOPE OF THE MODEL

- We can make this module totally autonomous using OpenCV. Since the work of this model is to reduce human labour and increase the efficiency of work, we can make this model completely autonomous and devise it according to real-time AI.

- This project is currently targeted to harvest tomatoes, but in future will be expanded to harvest horticulture crops like Brinjal, Ladies finger etc. The robotic arm can be used in AgroBot created by the Robotic club only. the robot is a robotic harvester specially designed to harvest strawberries on a large commercial scale. Our Robotic Arm can be very useful in this delicate work.

- We can use Carbon Fibre instead of Aluminium for commercial purposes. Carbon fibre is composed of carbon atoms bonded together to form a long chain. The fibres are extremely stiff, strong, and light, and are used in many processes to create excellent building materials. Hence using carbon fibre for commercial production will benefit the model in economical, sustainable and quality aspects.

- We can also put solar panels of 120W power output to recharge batteries during the job only thus increasing the life cycle of using a robotic arm but solar panels of this output will take quite size on the body

9 BILL

S no.	Components	Specification	Quantity	Price per unit (in Rs)	Total Price(in Rs)
1	DC Motor A	Operating Voltage-12V,Stall Torque-15kgcm,speed-1.1-1000rpm,dimension-10x10x20mm	4	275	1100
2	High Torque servo motors	Operating Voltage-4.8~5V,Torque-10kg cm,Operating speed-0.13s,Current comsumption-2A	3	350	1050
3	Small SG90 Servo	Operating Voltage-4.8V~6.0V,Torque-1.6kg/cm,Operating ,Weight: 9g	3	130	390
4	DC Motor B	Operating Voltage-12V,Stall Torque-15kgcm,speed-1.1-500rpm,Dimension-10x10x20mm	1	275	275
5	High Torque servo motors	Operating Voltage-4.8~5V,Torque-10kg cm,Operating speed-0.13s,360 degree Rotation	1	350	350
6	Motor Driver	L293 Motor driver	3	115	345
7	Ethernet Switch	Dimension-119x89x30mm, 4-port Gigabit Ethernet PoE Switch,Power-60W, Wifi type-802.3af	1	360	360
8	Nvidia Jetson Nano	GPU-128-core Maxwell CPUQuad-core ARM A57 1.43 GHz,Memory- 2GB 64-bit LPDDR4 25.6 GB/s	1	4500	4500
9	Arduino UNO	14 digital input/output pins , 6 analog inputs,a 16 MHz ceramic resonator,	2	500	1000
10	Arduino Nano	Arduino Nano V3,14 digital input/8 analog inputs,	1	295	295
11	LiPo Pattery	Dimension-128x64x43mm,Voltage-12V,Nominal	4	1549	6196
12	Module+Antenna	5dBi whip antenna+M9 picostation module,data speed-100+Mbps, range-1-1.5km	1	800	800
13	Remote controller	Equipped with antenna, Range-1km,Frequency-900MHz,6 channels,2Joysticks	1	1100	1100
14	Aluminium		4.353kg	135/kg	588
15	Steel		2.943kg	195/kg	573
16	Wood	Oak Wood	4.179kg	93/kg	388
				TOTAL COST	19310

10 REFERENCES

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