Project No. 10

To verify the Grashof's law and measure the velocity of any link for a given velocity of crank using IR sensor.

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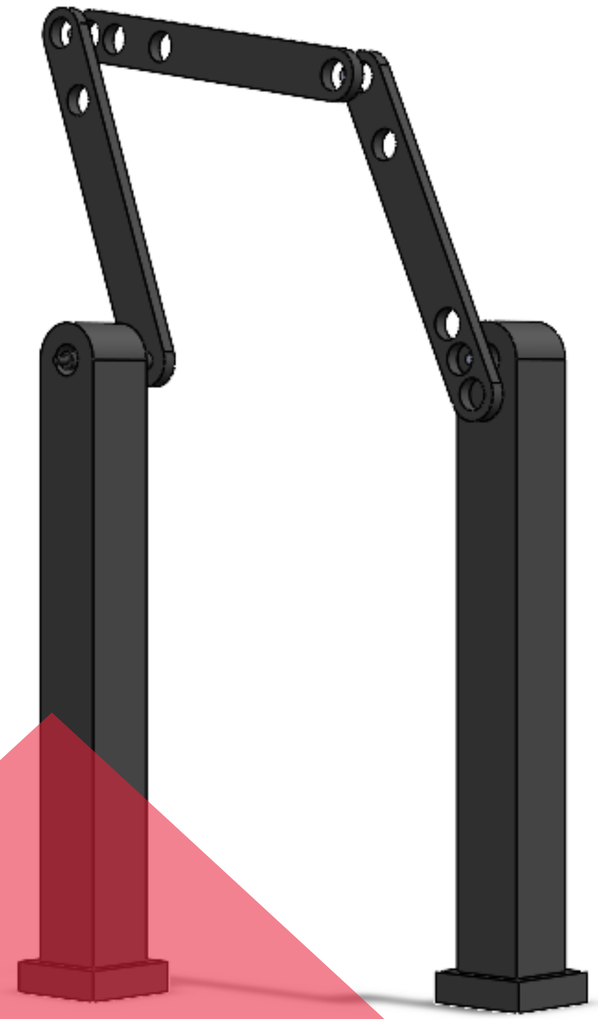


What is Grashof's law?

Grashof's law is a rule that states that in a four bar linkage, the sum of the shortest and the longest link lengths must be less than or equal to the sum of the other two link lengths for the mechanism to be able to achieve full rotation.

What are inversions?

Inversion of a mechanism refers to the process of fixing the links of a kinematic chain one at a time in order to obtain alternative mechanisms.

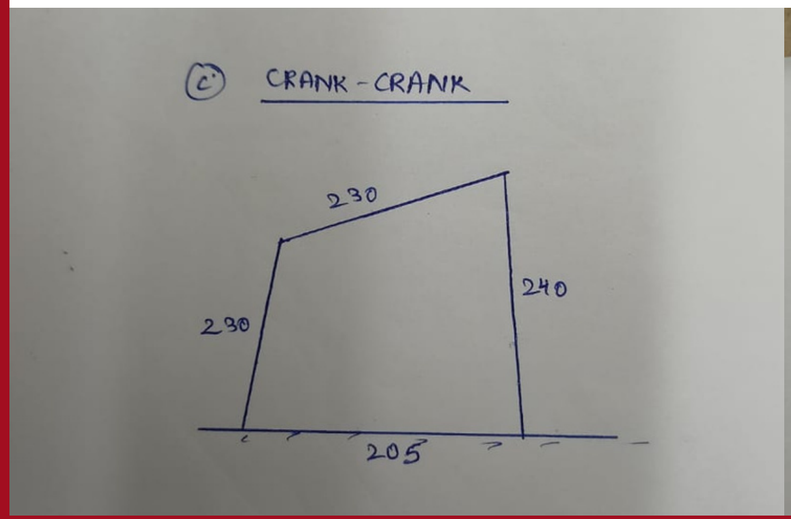
If the shortest link is fixed the resultant is crank-crank.

If the link adjacent to the shortest link is fixed the resultant is crank-rocker.

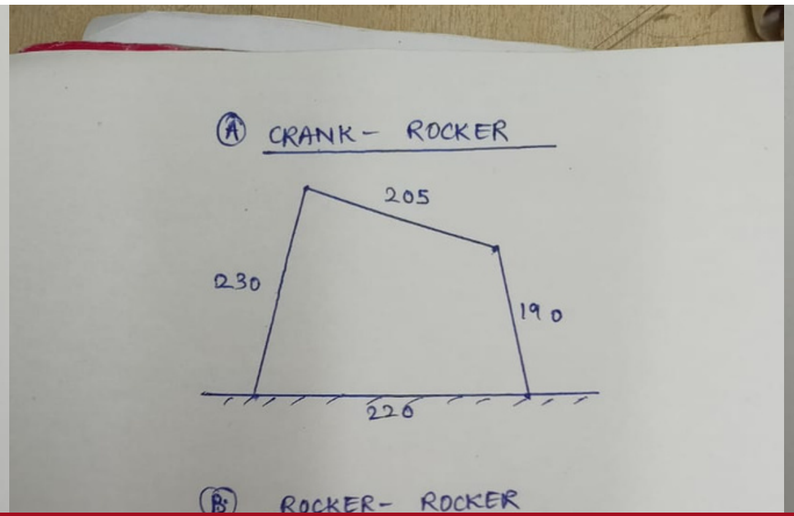
If the link opposite to the shortest link is fixed the resultant is rocker-rocker.

Inversions

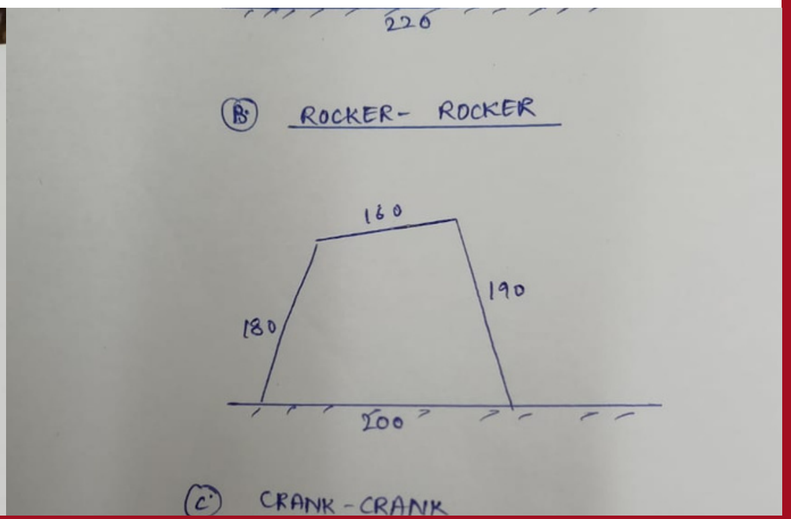
01 **Double crank**



02 **Crank-rocker**



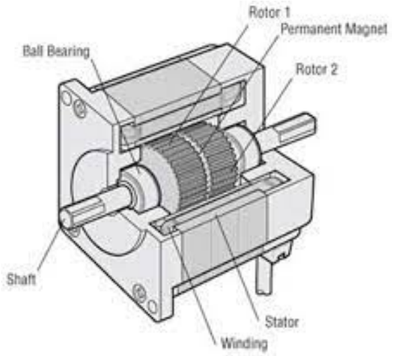
03 **Double rocker**



Components

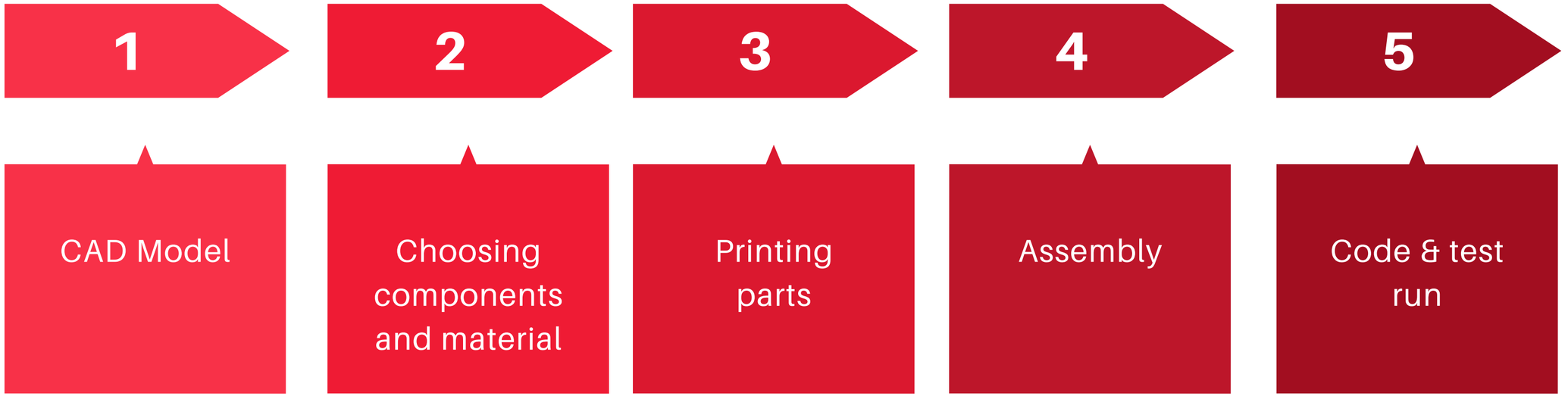
How they are used?

1	Acrylic sheet for stand: 10mm thick sheet is chosen to make a stand to support the motor is needed as the motor needs to be fixed with the link.
2	3D printed PLA links: The rods of the four bar mechanism have been 3-D printed.
3	Stepper motor - Provides torque to run the mechanism
4	IR Sensor - Attached with arduino to calculate speed of crank
5	Arduino - To code the stepper motor and IR sensor to measure the velocity of crank.
6	Bearings - 19mm inner dia bearings are used to join links and reduce friction so that the links can rotate easily with less torque required.



Motor Structural Diagram: Cross-Section Parallel to Shaft

How did we proceed?



Challenges

- Design a four plane mechanism to avoid collisions between links during inversions.
- To balance torques of links in vertical model.
- Avoid friction at the joint of two links.
- Use of high rpm motor and to place it.
- Keep the model light weight to reduce weight and torque required.

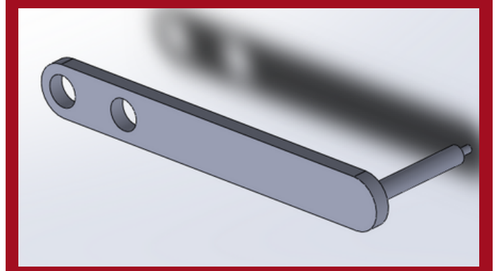
DESIGN

- For this project we have designed 3 rods with holes at different lengths.
- The purpose of the holes is to demonstrate the three cases in inversion, i.e. crank-crank, cranck-rocker, double rocker.
- We have made two supports which will act as one link and help in fixing the rods to the base.
- We have fixed bearings in the holes for rotation. A pin of appropriate dimensions has been designed to be inserted between the bearings.

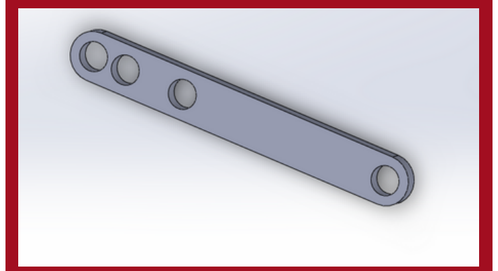
DIMENSIONS OF THE LINKS

- The input link is of 240 mm with hole at 190 mm at the other end.
- The total length of the coupler is 230 mm with holes at 205 and 160 mm at the other end.
- The length of the last rod is 230 mm with holes at 205 and 180 mm.

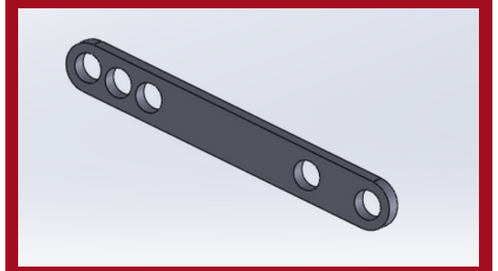
Input link



Coupler



Last rod



Code

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Blink

```
#include <AFMotor.h>
int ir_pin = 2;
volatile int count = 0;
unsigned long prev_time;
float rpm = 0.0;

AF_Stepper motor(200, 1);


void setup() {
    Serial.begin(9600);
    pinMode(ir_pin, INPUT_PULLUP);
  attachInterrupt(digitalPinToInterrupt(ir_pin), isr, FALLING);
  prev_time = micros();

  for (int i = 10; i<50; i= i+10){
     motor.setSpeed(10);  // 60 rpm
    motor.step(40, FORWARD, DOUBLE);
  }
}

void loop() {
    unsigned long current_time = micros();
  if (current_time - prev_time >= 1000000) {
    detachInterrupt(digitalPinToInterrupt(ir_pin));
    rpm = count * 600000.0 / (current_time - prev_time);
    Serial.print("RPM: ");
    Serial.println(rpm);
    count = 0;
    prev_time = current_time;
    attachInterrupt(digitalPinToInterrupt(ir_pin), isr, FALLING);
  }
  motor.step(100, FORWARD, SINGLE);
}

void isr() {
  count++;
}
```

Thank you