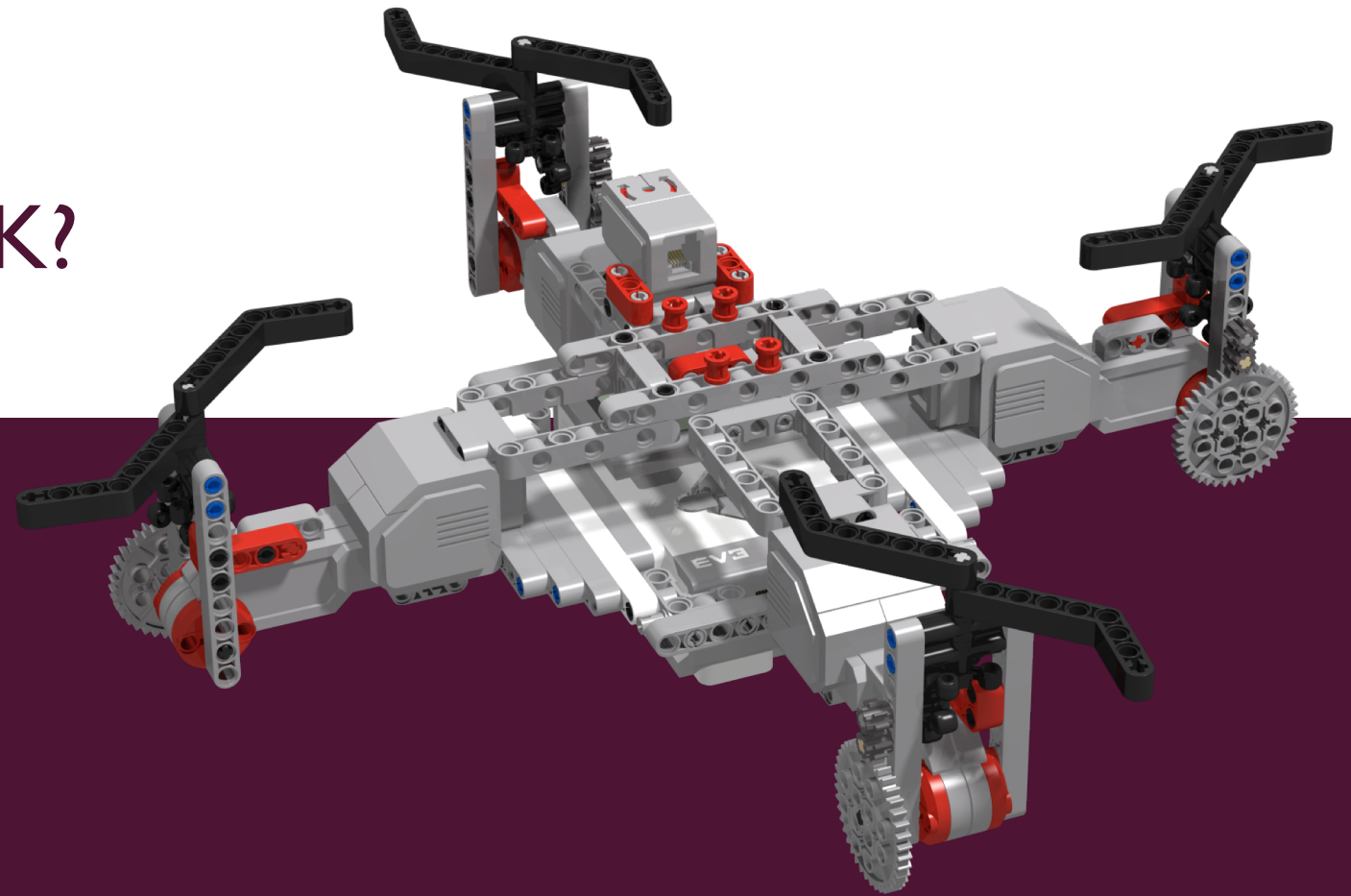# HOW DOES A QUADCOPTER WORK?

BY SANJAY AND ARVIND SESHAN

OBJECTIVES

- In this lesson you will learn the basic physics associated with a quadcopter

- You will build your own MINDSTORMS "Quadcopter" to see these physics principles in action
  - Note: You will not be creating a flying MINDSTORMS model – it is just meant to show the physics involved

WHAT IS A QUADCOPTER?

- Quadcopters use four propellers and four motors with propellers

- The use of four propellers allows the quadcopter to balance the different forces involved and maintain stable flight
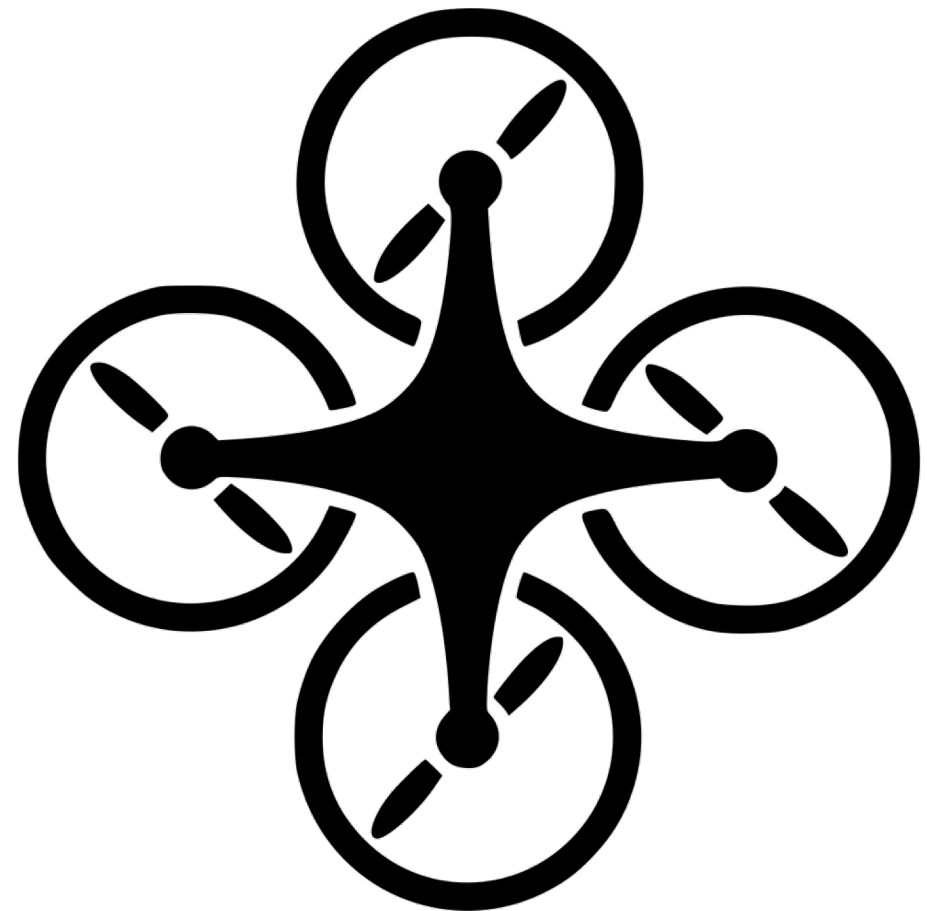
BUILD YOUR MINDSTORMS QUADCOPTER

- Use the Build Instructions provided

- As you build, connect the wires from the motors and gyro sensor to the ports as indicated in the image on the right

- Tie a long string through the middle of the frames at the center so that you can hang your quadcopter.
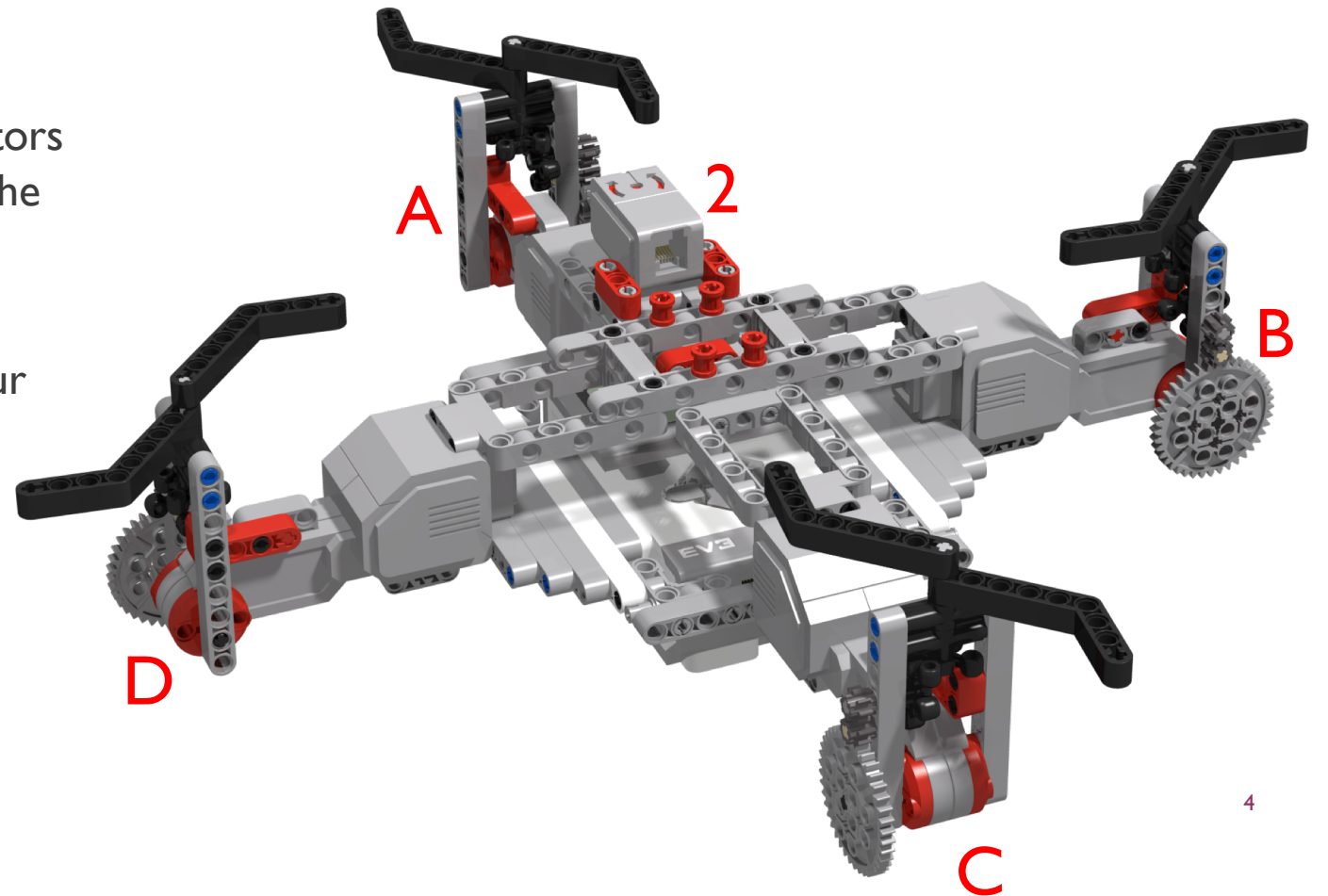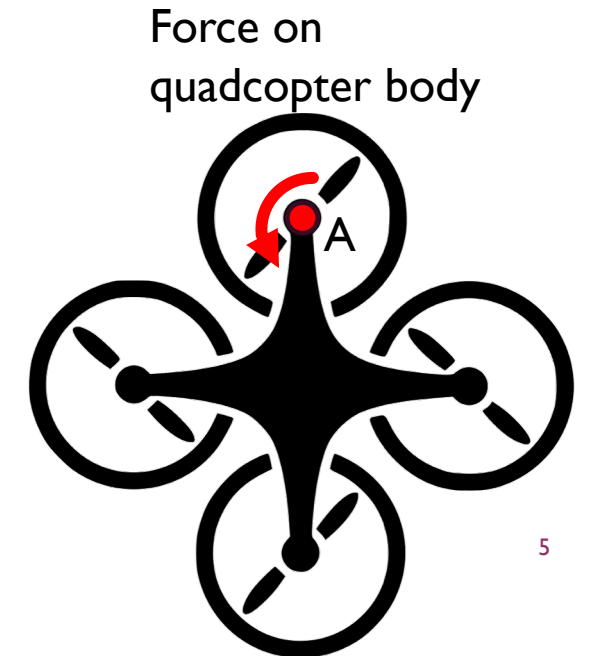
PROPELLER FORCES

- What would happen if you turned on a single motor?

- Newton's Third states "For every action, there is an equal and opposite reaction."

- To make the propeller turn, the quadcopter body must apply a force

- There must be an equal and opposite force applied by the propeller on the quadcopter body

- This will make the propeller spin in one direction around point "A" and the quadcopter body spin the opposite direction around point "A"
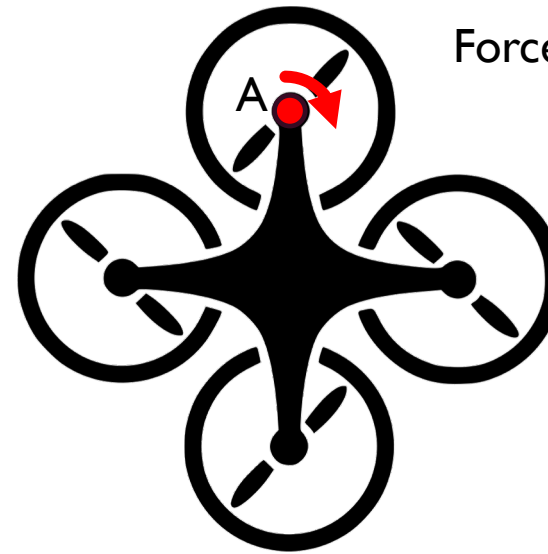
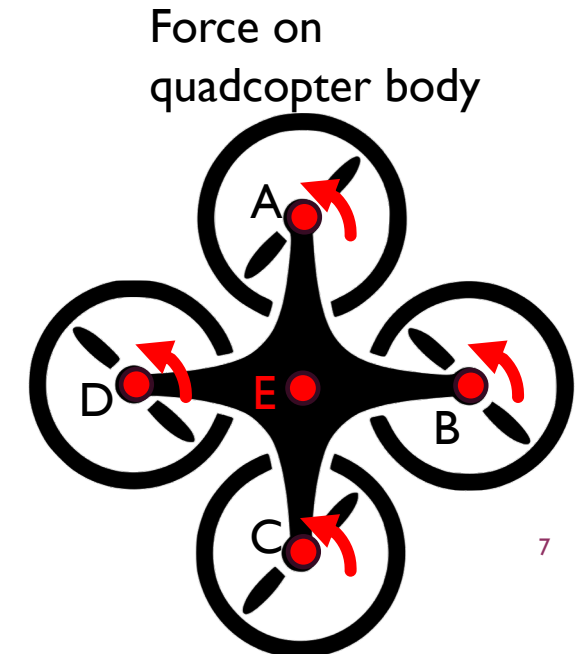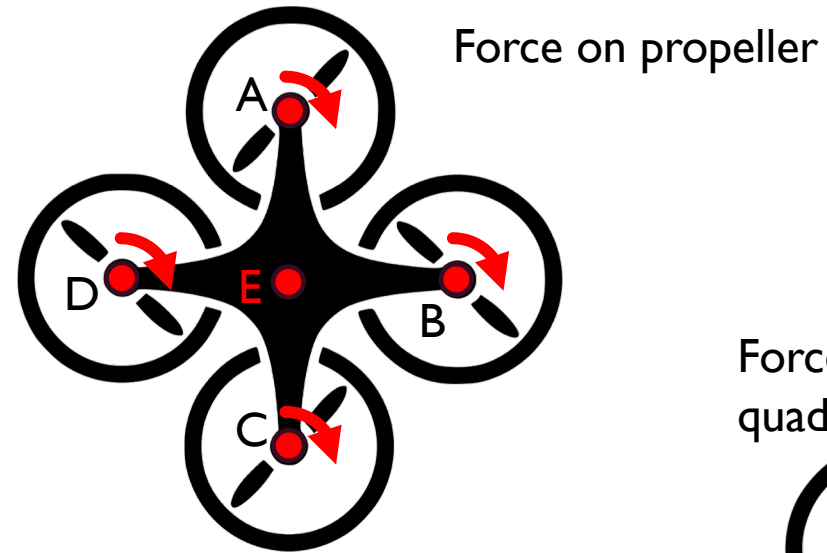Force on propeller

Force on quadcopter body

PROPELLER FORCES

- What would happen if you turned on four motors?

- Each propeller spins in one direction around its attachment point

- This applies an equal and opposite force at each of A, B, C and D

- The end result is that the body will spin around the center of the forces – it will spin counter-clockwise around point E

Force on propeller

Force on quadcopter body
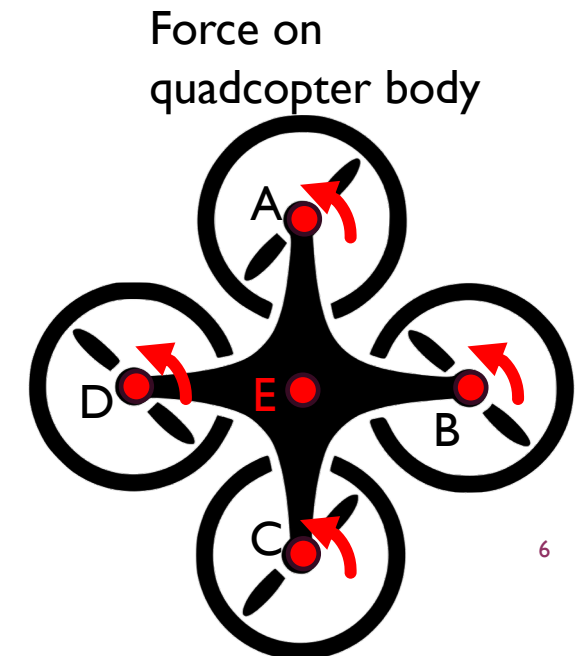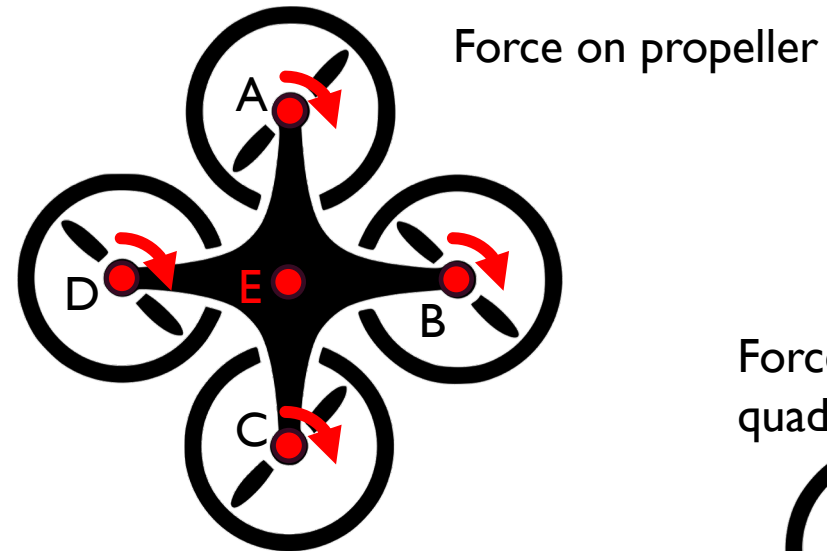
UNBALANCED FORCES

- Let's try this out..

- Write a program where all four motors are turning clockwise for 10 seconds

- You will begin by hanging your quadcopter

- Wait till the EV3 Quadcopter is still before running your program

- Observe what happens

Force on propeller

Force on quadcopter body

UNBALANCED FORCES CODE SOLUTION

▪ Because of propeller forces, the quadcopter spins when all four motors are turning clockwise
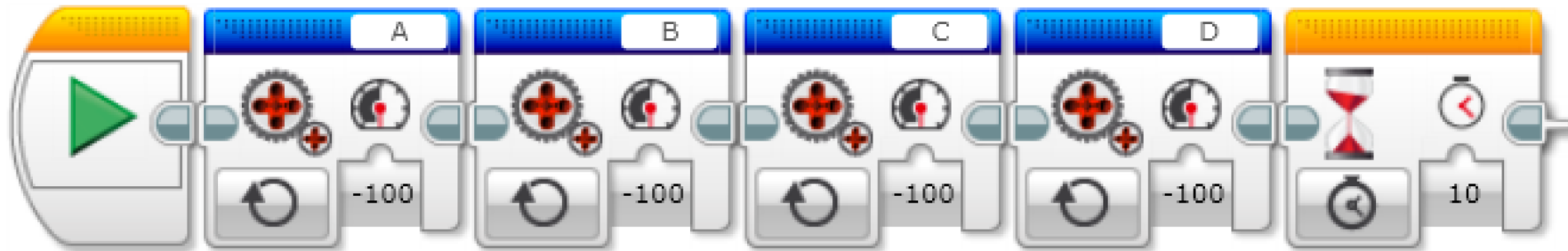
BALANCING FORCES

- How can we prevent the quadcopter from spinning when we turn on the motors?

    - We need to make sure that the forces balance out!

- Two motors rotates in clockwise(CW) and other two rotates in counter-clockwise(CCW).

    - Motors A and C rotate in clockwise and motors B and D rotate in counter-clockwise direction.

- If we look at the forces on the quadcopter body – each pair (A & C – and B & D) make the body spin around point E.

- However, the spin from each pair is an opposite direction and cancel out. The total angular momentum is zero.

- Write a program where all motors A &.C are turning clockwise and motors B & D are turning counter-clockwise for 10 seconds

Force on propeller

Force on quadcopter body

9
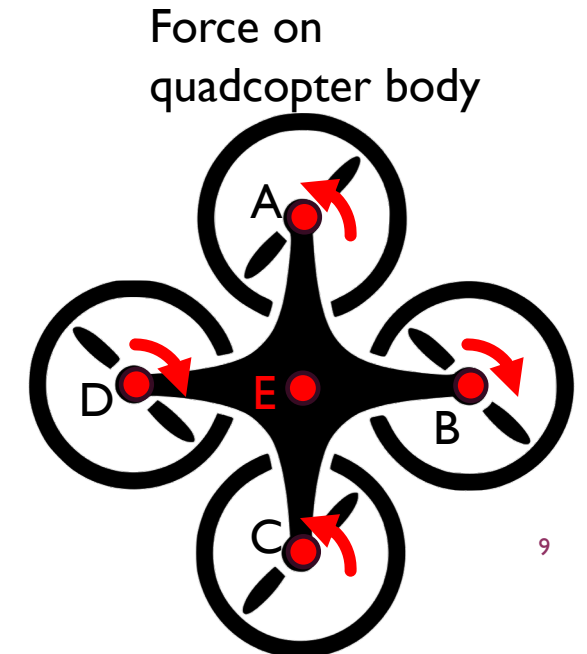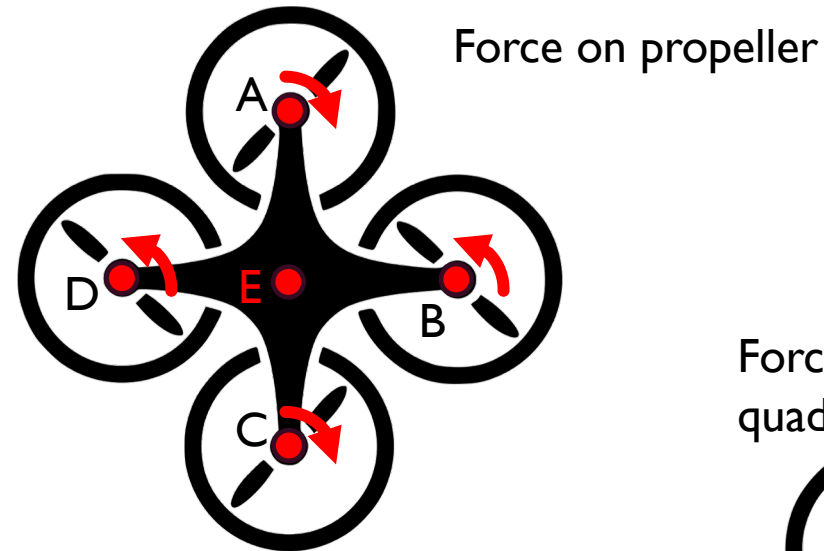
BALANCING FORCES CODE SOLUTION

- Because the forces balance out, the quadcopter stays still
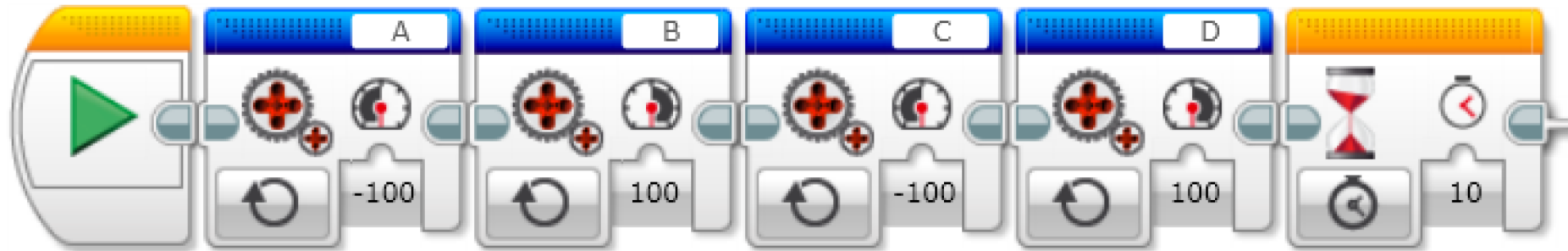
SUMMARY

In this real quadcopter…

B and D motors are rotating counterclockwise

A and C motors are rotating clockwise

With the two sets of quadcopter motors configured to rotate in opposite directions, the total angular momentum is zero. This prevents the quadcopter from spinning in an uncontrolled fashion