In this experiment, the DC generator is connected to the light pulley with two masses hanging from the cord over the pulley. An angular motion sensor is attached to the axis of the pulley to take quantitative data on the speed of the motion.

The EMF produced by changing flux of magnetic field is always appears in polarity that would create the current in the closed loop, reducing change of magnetic flux that produces EMF. This can happen if there is a coil, made of wire, in which this EMF creates the current. The smaller is the resistance of this loop the higher is the current and hence the larger is the torque in the direction opposite to the direction of rotation.

Connecting a resistor to the contacts of the DC generator closes the loop and the current in this resistor and the coil is proportional to the EMF and inversely proportional to the resistance of the resistor and the coil connected in series. When the contacts of DC generator are open (no current) the acceleration is defined by the component of the difference in forces of gravity acting on two masses and by a frictional torque. However, in case the resistor (or a bulb, or a LED in direct polarity) is connected between the contacts of the DC generator, the motion is quite different. The torque due to the current in the coil is proportional to the speed of rotation, and its direction is opposite to the direction of rotation. As a result, the hanging masses reach such a speed that the acceleration becomes zero, so the speed is constant. An increase in the difference of masses results in the motion with a higher limiting speed but still without an acceleration on the most of the way. Note the light from LED’s becomes brighter due to increased current.
Demonstration of the role of the Current due to Electro-Motive Force in an Atwood Machine Experiment.

Challenge

Building a model of the atwood machine with the LEGO RCX being the essential part of the design. One LEGO motor will be used not as a motor but as a generator. Axis of the motor is connected to the light pulley as well as the LEGO rotational sensor. The rotor of the generator will be rotated by the pulley due to the difference in masses hanging from it. The current through the coil of the generator is produced by the Electro-Motive Force (EMF) and controlled by the resistance of the load connected to the generator. In case the load is not a resistor but the LED (Light Emitting Diode which conducts current only in one polarity but not in the opposite one) the polarity of LED defines if the current due to EMF will or will not go through the LED. As a result the torque opposite to the direction of the rotation depends on the polarity of the LED.

Materials

RCX, parts for a 1-motor car (or an already made car).

Skills Learned

Design, Building, Programming.

Procedure

1. Build a LEGO model of the Atwood machine.
2. Connect LED to the 2×2 wire plate which should be connected to the generator and, for measuring the voltage on the LED, to one of the input ports (1-3).
3. Connect LEGO Rotation sensor to another input port for measuring the angular velocity.
4. Fasten the main block with pulley at some height on the post attached to the table and hang two different masses over the pulley using a light
5. When you release the masses they might start moving with a noticeable acceleration if LED is not emitting light (case 1) or they will move with apparently constant speed if LED is bright (case 2).

6. Change the direction of motion by changing masses on the string to switch between these two cases. The larger is the difference in masses the higher is the limiting speed of motion, the higher is the acceleration in case 1 or limiting speed (no acceleration!) in case 2.

7. Use data from collected from LEGO rotation sensor to build graph of angle of rotation as a function of time. You will see that the dependence is essentially a straight line the slope of which represents the limiting angular velocity.

**Lego Tips**

**Extensions**
1. any extensions that can be added to the activity

**Sample Program – Inventor 4**

Program for this experiment is very simple and includes only reading of the data on the LEGO rotational sensor.
Sample Project