Circadian Shades

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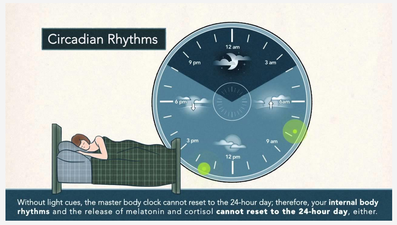
Problem Statement

Create an automatic opening window shade to combat the effects of Circadian Rhythm Disorder(CRD) at a low cost to consumers.

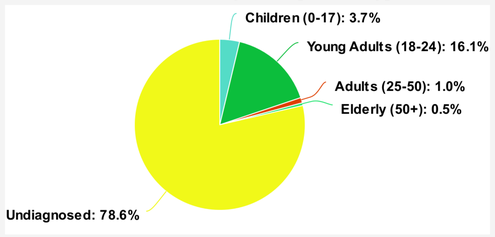
Circadian Rhythm Disorder



Background

- 7-16% of young adults experience some CRD
- CRD disrupts timing of sleep

Prevalence of Delayed Sleep Phase Type



Design Objectives

Create an Affordable Product
- Void in this market for a cheaper automated product

Create a Completely Dark Environment
- CRD requires a blackout sleeping environment

Automated Opening Mechanism
- Create a natural wake up experience for the user

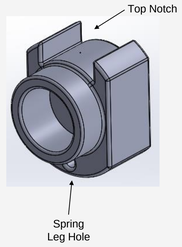
Concept Research

- Research conducted on various types of blinds
- Roller blinds were most feasible option
- Other options considered
  - Honeycomb Blinds
  - Drapes
- Manual pull down projector screen for influence
  - Utilizes torsion spring with ratchet mechanism
- Solenoid or servo motor to actuate pawl
  - Internal python timer to control speed and angle of rotation
- Considered initial torque expectations and speed of the raising of the blackout material
  - Researched rotational dampers to provide a slow and smooth raising of the blind material

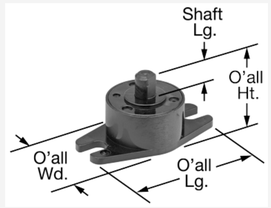
Final Designs

Rotation Block

Why It Works
- Top notch grabs the housing tube
- Spring attached through bottom hole
  - Spring torque translated to rotational motion raising the shade



Rotary Damper

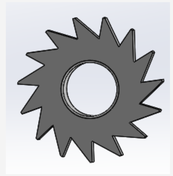


Specifications
- Limits rotational velocity to 50 RPM

Advantages
- Slow raising blinds to reduce noise and improve user experience

Ratchet Gear

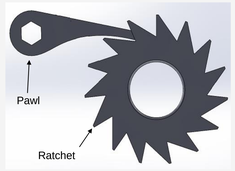
Function
- Allows the shade to be pulled down unimpeded
- Prevents Shade from raising when not desired



Change from Idea Genesis
- Projector screens employ an internal ratchet mechanism
- Circadian Shades utilizes and external ratchet mechanism
  - Allows pawl to be actuated freely
  - Creates an automatic opening shade

Pawl

Design to interface with the Circadian Shades ratchet gear, provides locking ability

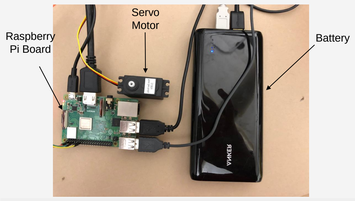


Torsion Spring

Specifications
- 0.072” gauge music wire steel
- 0.550” inner diameter
- 240 coils
- Maximum torque ~8in-lb

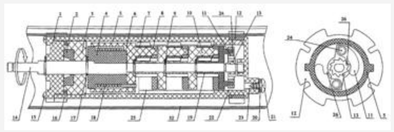
Reason for use
- Compact way to store mechanical energy to raise the shade
- Easy to apply to this design

Electronics



Function
- Wi-Fi control through SSH server
  - Reduced number of components
  - User can control through their phone

Design Process



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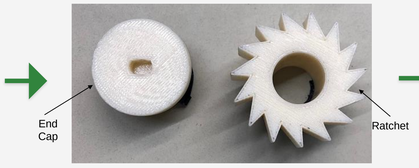
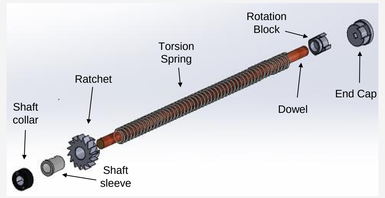




Idea Generation

Brainstorming
- Discussed three power mechanisms
- Torsion Spring, Counter weight, power screw
- Solenoid and timer to actuate pawl
- Reliability and Cost – Two highest priority constraints

Idea Refinement
- Pursued torsion spring only
- Solenoid versus rotary motor required further mock ups
- Narrowed choice of black out shade material and style

Part Mock Up

- Created individual parts for testing before final assembly

Pawl Activation Mock Up
- Attempt to actuate pawl with linear solenoid
- Utilized string/pulley and hook connection
- Discovered issues with these design concepts, moved to servo motor

Initial Part Prototypes
- Created initial 3D print parts for ratchet, pawl, and rotation block
- Performed fit and function testing to verify designs

Final Assembly Prototype

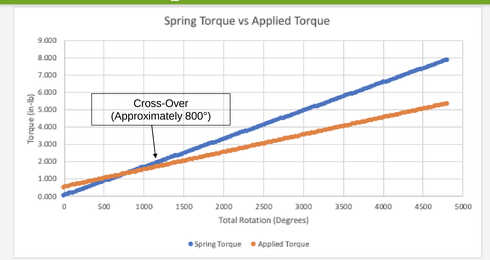
- Utilized for design verification
- Showed ratchet and pawl interfaced as desired to stop and release shade
- Optimized speed and efficiency of torsion spring lift mechanism

Software Improvements
- Moved from Arduino to Raspberry Pi
- Removed use of external timer in favor of internal digital timer

Test Process
- Ease of use with repeated deployment

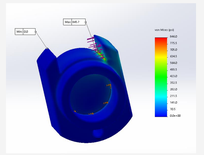
Prototype Cost
- Approximately $110

Torque Calculations

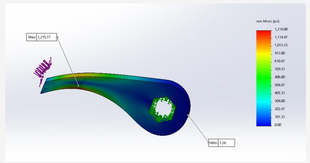


Net Torque has to be positive so that the shade rolls up. The blue line represents the torque provided by the torsion spring and the orange line represents the weight of the shade fabric. **3 Full Rotations** of pretension pass the cross-over point is needed to achieve this criteria.

Finite Element Analysis

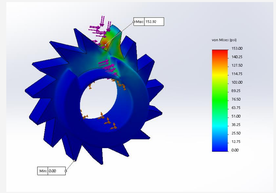


Rotation Block



Pawl

Identified critical stress areas for 3D printed parts to decide if material change was necessary for prototype



Ratchet Gear

Recommendations

- **Material Improvements**
  - Dowel – wood to plastic to control tolerance
  - Ratchet, Rotation Block, Pawl, and End Cap – optimize strength versus weight when considering using machined aluminum versus cast plastic
- **Manufacturing improvements**
  - Improve torsion spring installation process to bend spring legs to more precise locations
  - Implement stronger rotary motor i.e., stepper motor for greater reliability
  - Utilize larger housing tube for the spring system
- **Blackout Efficiency**
  - Implement ferromagnetic foil, plastic runners with gasket, or a magnetic hem-bar
  - Reduce light entering the bedroom environment through the sides of the blind
- **Testing Recommendations**
  - Lifecycle testing for reliability
  - Light testing with production design