College of Engineering
LAMAR UNIVERSITY

The Clip Crew

Bike light attachment with either clip or carabiner

Bike light system with tool-free installation and easy removal.

Product Design: Our design features a bike light with a modular attachment system, using either a clip or a carabiner, modeled through parametric CAD techniques. Fusion 360's Static Stress FEA tool will be used to simulate mechanical performance under load, with stress, deflection, and safety factors evaluated through key engineering equations.

CAD modeling with parametric modeling

CAD modeling is creating a digital 3D model of a part or assembly using computer Aided Design (CAD) software. Parametric modeling is a type of CAD where the geometry is driven by parameters like dimensions, formulas or relationships. Instead of manually redrawing a model to change it, you adjust the parameters and the model automatically updates.

Bike light with a Clip Mechanism

Utilizing parametric principles to define clip radius, thickness, and tolerance, ensuring the clip securely attaches to the handlebar

Equation:

$$R_{clip} = \frac{D_{bar}}{2} + T$$

Where:

- R_{clip} = Clip radius
- D_{bar} = Bar Diameter
- T = Tolerance

For example, with a handlebar diameter of 22.2 mm and the tolerance being 0.3 mm

$$R_{clip} = \frac{22.2}{2} + 0.3 = 11.4mm$$

Bike Light with Carabiner Mechanism

As an alternative deign, creating a carabiner style latch featuring a rotating spring gate is an option. This approach will involve modeling the carabiner's curved body using circular arc equations.

Equation for Carabiner Arc:

$$x(\theta) = Rcos(\theta) \quad , \quad y(\theta) = Rsin(\theta)$$

Where:

- R = Desired radius of the carabiner arc
- θ = Sweep angle of radius

Additionally, we'll define the clearance for the spring-loaded gate as:

$$C_{gate} = D_{strap} + M$$

Where:

- C_{gate} = clearance between the gate and the inner curve
- D_{strap} = diameter or width of the handlebar/strap
- M= margin of ease for latching
  - Usually around 1-2 mm

Structural Simulation

Fusion 360's Static FEA tool will be utilized to simulate the mechanical performance of the clip or carabiner under applied loads. The following equations will be employed to evaluate stress, deflection, and safety factors.

Equations:

Stress: $$\sigma = \frac{F}{A}$$

Deflection (Cantilever Beam):

$$\delta = \frac{FL^3}{3EI}$$

Where:

- F = applied force
- L = length of clip arm
- E = Young's Modulus of PLA
- I = moment of inertia of cross-section

3D Printing Path Optimization

For the prototype, the plan is to optimize print orientation and settings to maximize strrngth and efficiency

Key Equations:

Print Time:

$$t_{print} = \frac{H}{h} * t_{layer}$$

Where:

- H = part height
- h = layer height
- t_{layer} = time to print one layer

Mass Estimation:

$$Mass = Effective\ Volume \times Density$$

Calculations will allow to estimate both the total print time and mass of the prototype.

Prototype

The prototype is made up of a tiny, light module that is less than an inch thick, 2.5 inches long, and 1.5 inches broad. To increase grip and survive a variety of environmental conditions like rain, dirt, and dust, the shell will be composed of sturdy, weather-resistant ABS plastic with a textured, matte finish. To comply with Texas Transportation Code § 551.104, the front surface will contain a high-efficiency LED array that can produce both steady and flashing light modes in red (for rear-facing use) and white (for front-facing use). The light intensity will be adjustable with a simple one-button interface positioned on the top of the casing for easy access, even when wearing gloves. With the help of an integrated, robust clip made of flexible, reinforced nylon on the back, the device will be able to firmly fasten to a variety of surfaces, including handlebars, seat posts, backpacks, and clothing. The spring-loaded construction of the clip will provide a secure hold without the need for tools during installation or removal. The clip will have a rubberized backing to improve stability and stop slipping when riding. An IEC 62133-compliant rechargeable lithium-ion battery will be inserted inside the enclosure, offering an estimated 6–8 hours of continuous use at medium brightness. To ensure waterproofing, a shielded USB-C connector beneath a rubber cover will be used for charging. Additionally, the mockup features a user-friendly battery indicator: a tiny, multicolored LED light that, while the main light is out, tells users of the battery's charge level (green for full, yellow for medium, and red for low). The total weight of the unit will be less than 100 grams, guaranteeing that it won't have a major impact on user comfort or bike handling.

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