FOCUS GLASSES

PRODUCT DESIGN SPECIFICATION

MAE 5340
Innovative Product Design

ISABELA CASTILLO
(ic425)

RENE UMEH
(rcu8)

SWAR SAHGAL
(ssk4479)

JEFFREY KAGLE
(jak567)

ROBERT BRIDGES
(rcb354)

TABLE OF CONTENTS

1. Product Description Executive Summary 4
1.1 Team Name and Summary of Participants 4
1.2 Product Name 4
1.3 Problem you are solving 4
1.3.1.Reddit, Amazon Reviews, other evidence of problem 4
1.4. Product hypothesis 4
1.5. Picture of highest level product refinement 5
1.6. Net Present Value of Opportunity 5
2. Physical Description 6
2.1. List of Customer Requirements (C.R.'s) 6
2.2. List of Engineering Parameters (E.P's) of Concept 10
2.3. House of Quality – C.R.'s vs. E.P.'s
2.3.1What Engineering contradiction(s) are you solving for? 10
2.4. Use of TRIZ throughout iterations PG
2.4.1.1 Substance Field Analysis PG
2.4.2 What are the historical solutions PG
2.4.2.1 TRIZ solution PG
2.4.2.2 Competitor examples PG
2.4.3 What is your proposed solution
2.4.3.1 How do you apply TRIZ Solution to your specific problem PG
2.4.3.2 What specific technical innovation is solving your problem PG
2.5 What is the Embodiment of your Solution PG
2.5.1 Summary and analysis of Choice Based Conjoint results PG
2.5.1.1 What hypotheses were being tested? PG
2.5.2. Evolution of prototypes with explanations about the changes and what was being tested with each version. PG
2.6.Mechanical Analysis of Key Features PG
2.6.1. Analytical PG
2.6.2. FEA 18
3. Market Identification 18
3.1. Target Market 18
3.1.1.Market Size – IBISworld/other market reports 18
3.2. House of Quality – Competitive Analysis
3.3.Pricing Policy
3.3.1. Derived from Conjoint and other observations
3.4.Bass Model Forecasting to predict product demand
3.5.Production Costs

3.5.1. What manufacturing process will you use? Justify using charts from manufacturing lectures.
3.5.2. Tooling parameters and costs
3.6.Cost of Goods Sold
3.6.1. Materials, labor, off the shelf components
3.7.Net Present Value detailed analysis 34
4. Legal Requirements 34
4.1.Required or Recommended Certifications
4.2.Potential Liability Issues
4.2.1. Prediction of Misuse Cases
4.2.1.1. Failure Mode and Effect Analysis
4.3 Intellectual Property Considerations?
4.3.1. Pursue Utility, Design patents? Why?
4.3.2. Trade secrets? Why? 38
5. Sources 39
5.1. Bibliography 39
5.2. Appendices 41
A. HOQ 41
B. NPV Spreadsheets 42
C. Bass Model Functions (Python) 44
D. Product Gallery 46

1. Product Description Executive Summary

1.1 Team Name and Summary of Participants

Team Name: **STEN Labs**

Summary of Participants: **Robert Bridges, Rene Umeh, Jeffrey Kagle, Swar Sahgal, & Isabela Castillo.**

1.2 Product Name

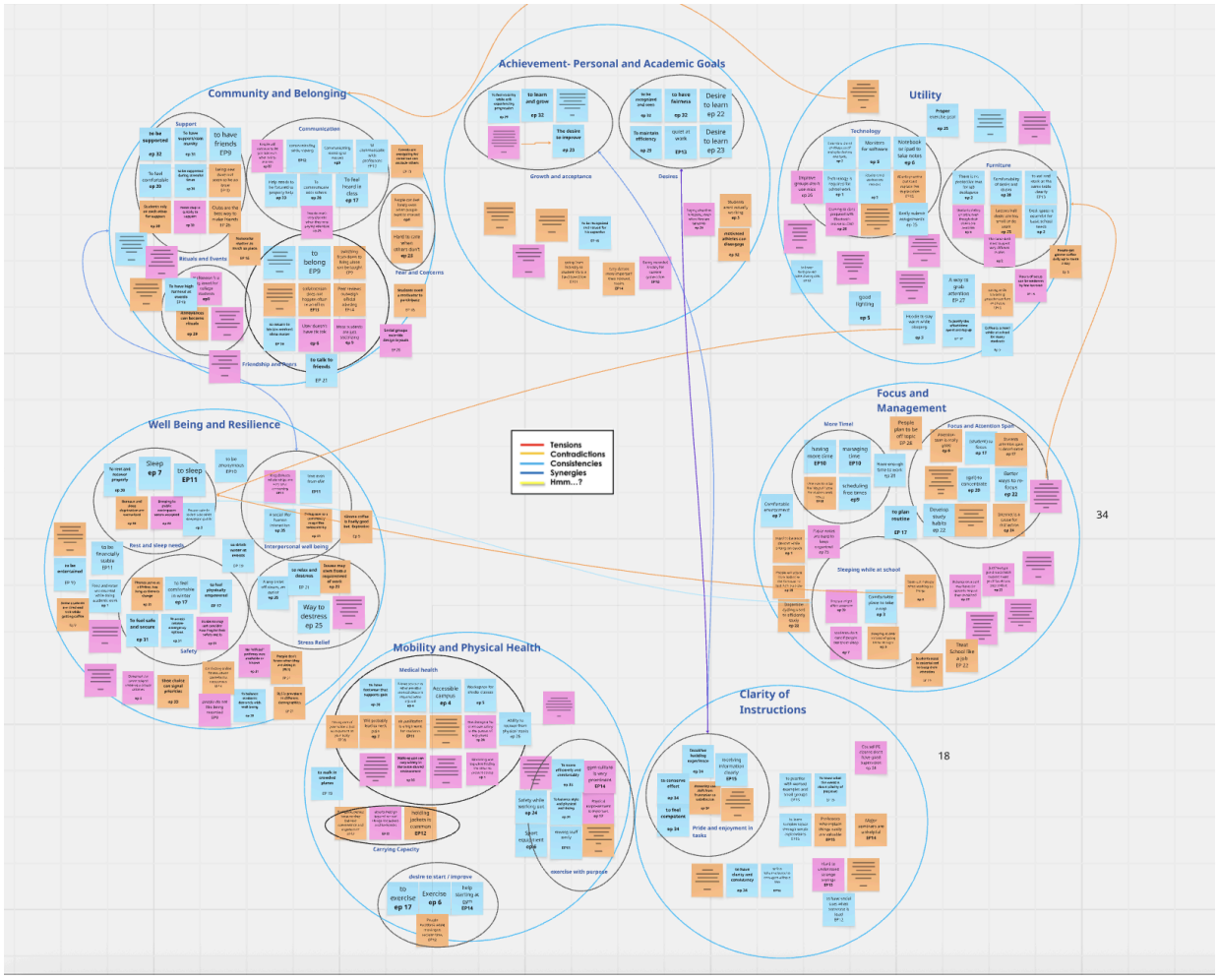
Product Name: **Focus Glasses**

1.3 Problem you are solving

- Students struggle to stay focused during long lectures, often dozing off or getting distracted.
- Users (students, designers, professionals) struggle with maintaining focus for prolonged periods.
- Current solutions include productivity apps or smart glasses, though neither addresses the problem effectively.
- Develop a cost-effective and reliable product that helps users maintain focus.

1.3.1.Reddit, Amazon Reviews, other evidence of problem

We performed investigations into the problems facing Cornell students at different levels of education. Through 50 episodes of immersion, observations, and interviews, we identified recurring barriers to academic success, well-being, and resource accessibility, and synthesized these insights into actionable opportunity areas. Of all the subcategories of problems we analyzed, ‘Academic Achievement’ and ‘Focus and Management’ ranked as the most critical according to our AHP analysis. This finding helped us narrow down our focus and became the foundation for developing a product to allow students to improve their focus and management capabilities.



Inconsistent

	Community and Belonging	Well Being and Resilience	Mobility and Physical Health	Achievement	Focus and Management	Clarity of Instructions	Utility
Community and Belonging	1.00	1.00	0.20	0.14	0.11	1.00	1.00
Well Being and Resilience	0.33	1	1.00	0.25	0.14	3.00	1.00
Mobility and Physical Health	1.00	1.00	1.00	0.20	0.14	1.00	2.00
Achievement	3.00	3.00	3.00	1.00	1.00	5.00	3.00
Focus and Management	5.00	3.00	3.00	0.33	1.00	5.00	1.00
Clarity of Instructions	0.11	0.14	0.11	0.11	0.11	1.00	0.14
Utility	0.14	0.20	0.33	0.11	0.11	2.00	1.00
sum	10.58	9.34	8.64	2.14	2.61	18.00	9.14

	Community and Belonging	Well Being and Resilience	Mobility and Physical Health	Achievement	Focus and Management	Clarity of Instructions	Utility	weights
Community and Belonging	0.09450803318	0.1070663812	0.02314517166	0.06531881804	0.0425170068	0.05555555556	0.1094091904	0.071074308
Well Being and Resilience	0.03118765095	0.1070663812	0.1157258583	0.1166407465	0.05357142857	0.1666666667	0.1094091904	0.100038274
Mobility and Physical Health	0.09450803318	0.1070663812	0.1157258583	0.0933125972	0.05357142857	0.05555555556	0.2188183807	0.105508319
Achievement	0.2835240995	0.3211991435	0.3471775749	0.466562986	0.3826530612	0.2777777778	0.3282275711	0.343874602
Focus and Management	0.4725401659	0.3211991435	0.3471775749	0.1555209953	0.3826530612	0.2777777778	0.1094091904	0.295182558
Clarity of Instructions	0.01050089258	0.01498929336	0.0128584287	0.05132192846	0.0425170068	0.05555555556	0.01531728665	0.029008627
Utility	0.01323112465	0.02141327623	0.03818953324	0.05132192846	0.0425170068	0.1111111111	0.1094091904	0.055313310
sum	1	1	1	1	1	1	1	

Weight sum vector	Criteria weights	Priority Vector
0.3574766905	0.08796050408	4.064059139
0.4986345167	0.2303015073	2.165137878
0.5263566283	0.2303015073	2.285511
1.779902934	0.08374869971	21.25290231
1.582175195	0.07698632095	20.55138076
0.1410024095	0.2137151397	0.6597679963
0.2487306367	0.07698632095	3.230841968
	principal eigenvalue (lambd	7.744228722
	consistency index (l-n)/(n-1)	0.1240381204
	consistency ratio, CR/RI	0.08554353132

1.4. Product hypothesis

Light-based gamma entrainment with novel invisible spectral flicker stimuli | Scientific Reports

Our literature review on the link between audio-visual stimulation and cognitive performance [1], [2] revealed that the gamma stimulation that comes from this methodology, while explored primarily for Alzheimers' treatment, can offer acute cognitive benefits in healthy adults. A controlled study on the impact of 30Hz visual flicker against constant light and random flickering offered promising results. EEG measurements that were taken during vigilance tasks across the three control groups highlighted a correlation between the 40Hz flicker and reduced delta activity, which has been linked to attention deficiencies, decreased alertness, and transitions toward sleep-like states [3].

As such, we propose that integrating similar low-intensity 40 Hz LED cues into a modern wearable, our focus glasses, can provide gentle, ambient prompts that help students stay attentive during work sessions and during class.

We hypothesize that a functional prototype can be developed within 8–10 weeks with the following specifications: integrated 40 Hz micro-LED modules with <7 mm arm thickness, battery life of 4+ hours continuous use, total device weight under 60 grams, USB-C charging with sub–2 hour full recharge, adjustable brightness to comply with visual comfort standard.

1.5. Basic Functions of Product to solve problem

- **Sustained Flicker** – Flicker from white to off white yellow at a rate of 40 Hz. To stimulate gamma brain activity while diffusing delta brain activity.

- **Lightweight & Portable** – Comparable to traditional glasses to address user reservations.
- **Strong Battery Life** – Survives the longest stretch of a single class period (~2-3hrs)

1.6. Net Present Value of Opportunity

The Focus Glasses have an intended use of being a lightweight wearable system to aid students in maintaining focus during lectures, study sessions, and other tasks that demand constant attention over a prolonged period of time. Given the novel nature of our solution, no such system currently exists on the market. Because no comparable product currently exists in the academic-focused wearable technology space, we expect adoption to be driven primarily by curiosity, affordability, and the growing openness to non-pharmacological focus-enhancing tools.

2. Physical Description

2.1. List of Customer Requirements (C.R.'s)

The Focus Glasses' customer requirements are derived from analyzing needs of students across disciplines, like engineering, architecture and business, whose schedules demand extended periods of attention and focus.

Our user research revealed two primary requirements: comfort, as users are already wary of smart wearables that can be heavy or run hot very quickly; and being discreet, so as to not provide a solution at the expense of others' attention and/or focus.

The question of lenses was brought up and is an essential consideration in making frames that can accommodate prescriptions and do not reflect the flicker through transition or blue light glass.

Battery longevity and overall durability ensure performance during extended study and class sessions and complete our core set of customer requirements.

These carefully distilled requirements formed the foundation of our House of Quality analysis and guided our engineering targets and subsystem selection throughout development, enabling us to create a solution that addresses attention lapses and distractions in an intuitive form factor.

Customer Requirement	Description

Comfortable and safety	Must sit lightly on the face with proper weight distribution, soft nose/temple contact points, and no pressure buildup over long lectures and must stay cool without hotspots.
Minimal distraction to others	No visible lights that could divert attention from nearby students or teachers.
Battery longevity	Should last through the longest stretch of a single class and additional study time thereafter, so students can maintain flow states (~4 hrs constant use).
Durability / robustness	As a stand in for traditional glasses, students should not feel the need to take extra care and so the ability to withstand daily backpack transport, drops, desk tossing, and general student lifestyle

2.2. List of Engineering Parameters (E.P.'s) of Concept

The engineering parameters (E.P. 's) in the Focus Glasses project were derived from our House of Quality, mapping nine customer requirements to six core functional elements that serve as measurable design levers ensuring technical decisions satisfy user needs. Each parameter was selected both for its individual contribution and its ability to connect multiple customer needs through shared components.

List Of Components

Component Name	Specification	Functional Element
PCB Board	Custom PCB board	Used to hold and connect all the electronic components, including the LEDs.
Microcontroller Unit	579-ATTINY202-SSN	Small MCU used to control the LED frequency
LED	Wurth Multi-Color LEDs	RGB LEDs used to create the

		invisible spectral flicker
CR1220 Battery	3 V Lithium	Power for MCU and LED
CR1220 Coin Cell Holder		Holds Battery in place
Slide Switch	100 mA, 12 V	On and off power
Resistor	270 Ω	Current limiting resistor for Red LED channel
Resistor	180 Ω	Current limiting resistor for Blue LED channel
0.1 µF Ceramic Capacitor	0.1 µF	Power supply decoupling for ATtiny202
OLED		Alternative for invisible spectral flicker display
Arduino Nano		Arduino MCU to control the oLED screen

E.P. #	Engineering Parameter	Functional Element
1	**Weight**	Frame material, battery, PCB, LEDs
2	**Battery Capacitance**	Battery cell, power-management circuitry
3	**LED size**	LED package, optical housing/diffuser
4	**Radiance**	LED driver, LED emitter, diffuser/light-guide
5	**Max surface temp**	LED thermal path, heat spreader/frame material
6	**CoG to geometric center**	Battery placement, PCB placement, temple mass distribution

2.3. House of Quality – C.R.'s vs. E.P.'s

The figure shows our House of Quality matrix mapping customer requirements to engineering parameters.

		ENGINEERING CHARACTERISTICS					
IMPROVEMENT DIRECTION		↓	↑	↓	↑	↓	↓
UNITS		kg	mAh	mm	lux	Celcius	mm
CUSTOMER REQUIREMENTS	Importance Weight Factor	Weight	Battery Capacity	LED size	Radiance	Max Surface Temperature	CoG to geometric center
Lightweight	3	9	5	3	1	0	9
Balanced	2	5	5	3	1	0	0
Affordable	2	3	3	3	0	0	0
Comfortable	4	9	3	1	1	9	7
Durable	4	3	0	0	1	7	0
Discrete Appearance	4	3	1	9	1	0	5
Effective	5	1	5	5	9	0	0
Safe	5	0	3	0	9	9	0
Easy to Use	4	3	0	3	1	5	9
Score		120	87	98	111	129	111
Relative weight		18.29	13.26	14.94	16.92	19.66	16.92
Rank Order		2	5	4	3	1	3

2.3.1 What Engineering contradictions are you solving for?

- Cost Vs. Functionality: Our competition will be other smart glasses (I.e. Meta-glasses) that can easily replicate our technique. However, our competitors are much more expensive and complex than our design so we must make our product as cheap as possible to stay competitive. This conflicts with our want to

create a functional product that can meet as many user wants as possible such as feedback and EEG sensing.

- Utility Vs. Form Factor: While circuitry is minimal, it adds a design constraint to our form factor. For example, traditional slim, metal frames cannot be accommodated due to lack of space to embed circuits, vs more casual models (see RayBans) that offer a larger surface area/enclosure space in the frame and/or arms for embedded systems.
- Battery Life Vs. Weight: Our customers want a high battery life to ensure that the device can be used for multiple iterations before needing to be recharged. A larger battery comes at the cost of increased weight and size of the device.
- Effectiveness Vs. Visual Interference: Having a device that is slim or has a large flashing light comes with the risk that excess light pollution may distract other students or intrude on everyday life. This must be balanced with ensuring that our device completes its goals to the fullest extent and matches our customer desires.

2.4. Use of TRIZ throughout iterations

The iterative design of the Focus Glasses was guided by TRIZ principles as we addressed functional contradictions in modern input devices. Our device navigates a compromise between utility and form factor, cost and functionality, effectiveness and visual interference, and battery life and weight. We resolved these tensions using Substance Field Analysis, contradiction mapping, and inventive principle application to develop innovative solutions that satisfy competing requirements simultaneously.

2.4.1.1. Substance Field Analysis

To understand how the components of the Focus Glasses interact, we modeled them using TRIZ's Substance–Field (Su-Field) framework. A Su-Field model examines interactions between two substances (materials/parts) and a field (energy/force), helping identify where a system is missing a necessary interaction or creating an unintended harmful effect. To systematically understand and resolve these interactions, we performed a Substance–Field Analysis:

Identified Substances:

Substance	Description
S1	users' eye / retina
S2	LED modules producing 30 Hz flicker
S3	Lens/frame materials

S4	Electronics + battery embedded in the glasses arm
S5	Environmental light (ambient lighting conditions)

Identified Fields:

Field	Description
F1	Optical field (40 Hz light stimulation)
F2	Thermal field (heat from LEDs/electronics)
F3	Structural field (mechanical stresses on frame)
F4	Electrical field (power delivery + drive circuitry)

Interaction Flow:

- **S2 → F1 → S1:** Induce gamma-band stimulation without visible flicker.
- **S2 → F2 → S1:** Too much heat or radiance could exceed comfort/safety limits.

.

Identified Issues:

Our Su-Field analysis identified several key issues affecting the glasses' performance. The LEDs generate unwanted heat and occasional visible flicker, reducing comfort and undermining the subliminal effect. Ambient light can overpower the intended optical signal, while the frame's limited internal space constrains component placement and leads to uneven light delivery and localized hot spots. Mechanical stress from embedded electronics further risks frame deformation, and inefficient power distribution causes excess battery drain. Together, these issues highlight the need for improved thermal management, optical control, spatial integration, and power efficiency.

Su-Field Improvements Applied:

Problem	TRIZ-Inspired Solution
Heat build-up near face	Add thermal-dissipation pathways (Principle 24 – Intermediary) and reduce LED drive power using pulse-modulation rather than continuous output

Visible flicker at certain angles	Shift LED spectral output to wavelengths less detectable (Principle 32 – Color Change)
Ambient light drowning out 40 Hz flicker	Use collimating micro-diffusers to maintain stimulus only within users' visual field (Principle 3 – Local Quality)
Space constraints in frame	Integrate flexible PCBs to conform to curved temples (Principle 30 – Flexible Shells and Thin Films)

This Su-Field model allowed us to decompose a seemingly complex system into manageable, function-based units. Each pair (S1–S2, S1–S3, S3–S4, etc.) was evaluated for completeness and effectiveness, leading to specific improvements in mechanical layout, firmware filtering, and material shielding.

2.4.2 What are the historical solutions?

There are no current glasses which offer a similar function to the Focus Glasses. The closest historical solution would be smart glasses, but they do not have a similar feature. A solution which is commonly used is caffeine. However, the reliance of caffeine has its drawbacks beyond health considerations. A study by Doty et al. (2017) revealed that caffeine begins to lose its efficacy after 3 consecutive days of use; a factor that does not apply to our Focus Glasses. An additional consideration is that caffeine will stay in the user' system long after consumption with undesirable side effects, like restlessness and even crashing. In contrast, the Focus Glasses provide a clean stimulation and can be removed or switched off at any time, offering the user more control over their attention enhancing system [4].

2.4.2.1. TRIZ solution

To address the identified contradictions in thermal comfort, optical effectiveness, spatial constraints, and power efficiency, we applied TRIZ Inventive Principles to guide our design decisions. Local Quality (Principle 3) informed our targeted placement of LEDs and internal components, allowing us to concentrate optical output toward the retina while minimizing visible flicker and heat exposure elsewhere on the frame. Intermediary (Principle 24) drove the integration of a light-guiding diffusion layer that sits between the LEDs and the users' eye, ensuring uniform optical delivery while preventing glare and visual interference.

Dynamism (Principle 15) shaped the implementation of adaptive firmware that adjusts brightness and pulse parameters based on ambient light, preserving subliminal effectiveness without increasing user distraction. To overcome spatial limitations inside the eyewear arms, we used Segmentation (Principle 1) by distributing electronics into smaller, modular sections that follow the natural curvature of the frame, reducing bulk and mechanical stress. Finally, Merging (Principle 5) motivated the consolidation of sensor, driver, and microcontroller functions onto a

compact PCB, improving power efficiency and lowering thermal load while keeping the device lightweight and unobtrusive.

2.4.2.2. Competitor Examples

Meta Glasses are a pair of glasses with technology inside them. However, the functionality and purpose behind Meta Glasses compared to the Focus Glasses are drastically different. Yet, the model should be studied as an enhancing wearable piece of technology.

Caffeine also enables the user to stay awake, allowing them to focus. The largest difference is that caffeine has to be consumed and has a half life of five hours. The Focus glasses give you much more control and can be removed. Additionally, it takes time for the users' body to process caffeine, while the Focus Glasses are instantaneous.

2.4.3. What is your proposed solution?

Our solution integrates TRIZ principles into a unified platform addressing key contradictions efficiently. The Focus glasses take advantage of a phenomenon called “invisible spectral flicker". The glasses contain an LED which flickers between white and yellow light at 40 hz. Due to the frequency of the lights, the flicker goes unnoticed by the users, while also stimulating their retina. This stimulation is what keeps the user awake and focused.

At STEN Labs, the solution we are proposing is to integrate LED lights into wearable, fashionable glasses that can be worn during class or while doing work. Taking into consideration what was learned by the TRIZ solution as well as the house of quality, we have hypothesized that the best course of action to battle falling asleep in class and the overall lack of focus is to use a third party device, such as the Focus Glasses, to provide effortless stimulation.

2.2.4.1. How do you apply TRIZ solution (or other) to your specific problem

Our TRIZ principles were systematically applied to resolve the core contradictions in optical effectiveness, comfort, and spatial constraints. Local Quality guided the placement of LEDs and diffusers to concentrate optical output toward the retina while reducing visible flicker and heat in surrounding regions. Intermediary principles informed the use of a light-guiding diffusion layer that delivers uniform, subliminal illumination without creating glare. Dynamism enabled firmware-driven adjustments to brightness and pulse frequency based on ambient conditions, maintaining effectiveness while minimizing intrusiveness. Segmentation allowed us to distribute electronics along the natural curvature of the frame, improving fit and reducing bulk, while merging consolidated sensor, driver, and control circuitry onto a compact board to improve efficiency and reduce thermal load.

2.4.3.2. What specific technical innovation is solving your contradiction?

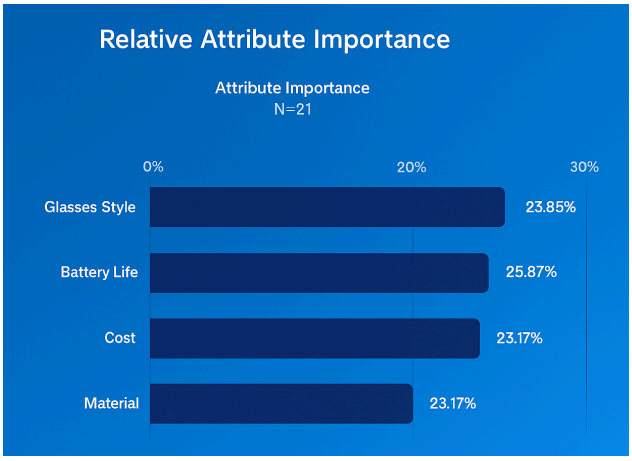
Our TRIZ principles were systematically applied to create practical engineering solutions. Dynamism is implemented through adaptive firmware that automatically adjusts LED brightness and pulse characteristics based on ambient light, preserving optical effectiveness while minimizing intrusiveness. Local Quality guided the development of a targeted optical system that uses micro-diffusers to direct stimulation toward the retina while preventing visible glare in the users' field of view. Intermediary principles led to the integration of a thin diffusion layer between the LEDs and the eye, ensuring uniform, subliminal illumination. Segmentation enabled us to distribute electronics along the curvature of the frame for improved comfort and weight balance, while Merging consolidated the microcontroller, driver, and sensor functions onto a single compact PCB, reducing thermal load and improving system efficiency.

2.5. What is the embodiment of your solution?

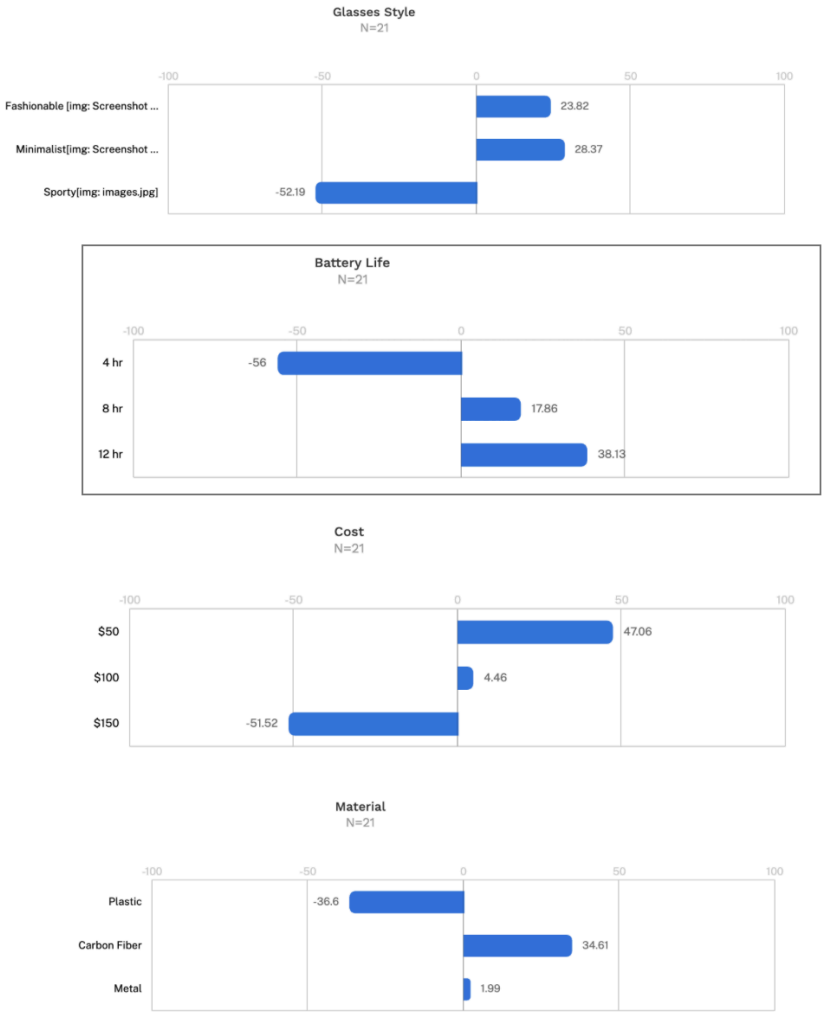
The Focus Glasses integrate optical, electronic, and ergonomic subsystems into a lightweight eyewear platform with thickened temple arms housing a compact PCB, LED driver, sensors, and a mid-capacity Li-ion battery. Micro-LEDs near the front of each temple pair with an internal diffusion layer to deliver uniform, subliminal optical stimulation toward the retina. The frame is offered in either injection-molded polymer for affordability or a reinforced composite for improved rigidity and thermal performance. All components follow the natural curvature of the frame to reduce bulk, maintain balanced weight distribution, and preserve the appearance and comfort of everyday eyewear.

2.5.1. Summary and analysis of Choice Based Conjoint results

The figures illustrate both internal and external embodiments of the Focus Glasses. The assembled model shows a lightweight eyewear frame containing the full optical and electronic system. Exploded CAD views reveal the internal stack-up, including the embedded micro-LED modules, diffusion layer, compact control PCB with microcontroller and LED driver, and the Li-ion battery integrated along the temple arms. The layout demonstrates how the electronics follow the curvature of the frame to minimize bulk while maintaining balanced weight distribution and preserving the appearance of standard eyewear.



Conjoint analysis attribute weights



Conjoint analysis attribute specification

2.5.1.1. What hypotheses were being tested?

The figures illustrate both internal and external embodiments of the Focus Glasses. The assembled model was used to test hypotheses regarding comfort, weight distribution, and discreet form factor, ensuring that the embedded electronics did not compromise wearability. Additional hypotheses focused on optical effectiveness, including whether the micro-LEDs paired with the diffusion layer could provide uniform, subliminal stimulation without visible flicker or glare. Finally, the layout tested power efficiency and thermal management, verifying that the battery and electronics could sustain at least four hours of continuous use while keeping surface temperatures within safe limits.

2.5.2. Evolution of prototypes with explanations about the changes and what was being tested with each version

The figures illustrate both internal and external embodiments of the Focus Glasses. The assembled model shows the full eyewear system, including micro-LEDs, diffusion layer, compact PCB with microcontroller and LED driver, and Li-ion battery integrated along the temple arms. Exploded CAD views reveal how each component is positioned to optimize comfort, weight distribution, and discreet form factor. Early prototypes tested LED placement and diffusion for uniform retinal stimulation, while later versions focused on battery capacity, thermal management, and structural durability of the frame. Adjustments were also made to improve ergonomics and maintain the appearance of standard eyewear while housing the embedded electronics.

2.6. Mechanical Analysis

This section outlines the preliminary mechanical performance assessment of the Focus Glasses, the analysis presented here draws from published material properties for *ABS and aluminum*, estimated user force ranges *(2-10 N)*, and handbook-calculated stress limits based on component dimensions. This section will be updated once full finite element models are simulated and validated.

2.6.1.Analytical

Analytical estimates were used to assess whether the expected use forces—gripping, tapping, and scrolling—could exceed yield strength or cause structural failure.

Device dimensions and loading assumptions :

Temple cross section area:	~50 mm²

Maximum applied force (user press):	~10 N
Estimated applied stress:	$\sigma = \frac{F}{A} = \frac{10N}{50\times10^{-6}\ m^2} \approx 200kPa$

This is orders of magnitude below the yield strength for:

ABS	~40 MPa

Thus, under realistic conditions, ABS is not expected to deform plastically during use.

2.6.2.FEA

Finite Element Analysis was not performed on the Focus Glasses, as the device experiences minimal mechanical stress during normal use and does not involve complex structure that would require detailed simulation. Design verification was instead based on material selection, ergonomic testing, and durability assessments through physical prototypes.

Our biggest issue as stated in the HOQ is from thermal loading. Rather than using Ansys, circuit analysis can be used to first determine the power dissipated in the LED and then the thermal resistance of it.

First there are three 270Ω resistors in parallel on the PCB, therefore the effective resistance is 90Ω. Additionally the battery used produces 3V. We can assume the resistance within the PCB outside of the three resistors is negligible.

Forward voltage @ 20 mA:

- Red: 2.0–2.4 V
- Green: 2.8–3.4 V
- Blue: 3.0–3.4 V

Max power dissipation:

- Red: 48 mW
- Green: 68 mW
- Blue: 68 mW

LED parameters

Using a forward voltage of 2 volts, a battery of 3 volts, and a net resistance of 90Ω, we can calculate a net voltage of 1 volt over the resistors. Finding current;

$$I = \frac{V}{R} = \frac{1}{90} = \ 0.0111A$$

Noting the power formula;

$$P = VI = 2 * 0.0111 = 0.0222W$$

The voltage being used here is the forward voltage, not the net voltage. The power the LED will experience is 22mW of heat. From an LED safety stand point, we are well below the max heat values found in the Wurth Elektronik 155124M172400 (the specific LED we are using) datasheet. In terms of safety of the users we have to convert what the power is to temperature increase.

These specific LEDs have a range of 150 - 250 Junction to Ambient Thermal Resistance, in units of Celsius per Watt. The lower end translates to it has good cooling and the upper end has poor cooling. Multiplying both ends of the range by the calculated power will translate to the change in temperature from ambient.

$$\Delta T = P_{LED} * R_{\theta JA}$$

$$0.0222 * 150 = 3.3\,C$$

$$0.0222 * 250 = 5.5\,C$$

These two calculations give us a range of about 3 to 6 celsius above ambient temperature. Ambient temperature being 25 celsius, that is 28 and 31 celsius or 82.4 - 87.7 Fahrenheit. This heat is to be expected from an LED in use and is not a safety concern.

3. Market Identification

3.1. Target Market

Our target market consists primarily of students and adults who require sustained focus during cognitively intensive tasks. This includes both individuals seeking productivity enhancement and those who struggle with maintaining attention for extended periods.

Given the novelty of our wearable solution, our demographics' youth and technological openness present a favorable adoption environment. Additionally, our moderate price point makes the product accessible to student buyers.

3.1.1. Market Size – IBISworld/other market reports

According to DataIntelo, as of 2023, the current market for Smart Wearable Devices was $40 billion and is projected to reach around $150 billion by 2032, growing at a robust CAGR of 15% during the forecast period. While this is not specific to the product we are developing, it

makes a strong case for the ubiquity of wearables and the openness to adopt technologically enhanced eyewear.

Given the specificity of our product, we must rely on analogous data and reasonable assumptions to approximate our addressable market size. Recent studies report that approximately 11.1% of college students use non-prescribed pharmaceutical solutions for focus management link. When combined with survey data suggesting that upto 25% of students are open to trying technological eyewear link, we conservatively estimate our addressable market to be on the order of 500,000 potential users across American campuses.

3.2. House of Quality – Competitive Analysis

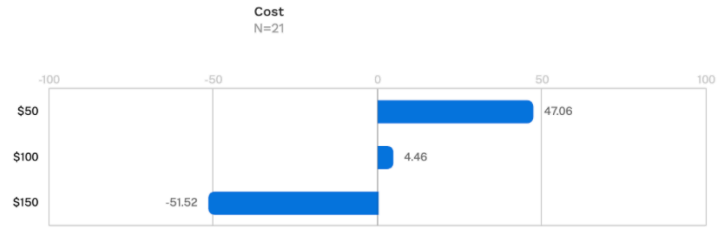
COMPETITOR RANKINGS 1-Poor, 3-OK, 5-Excellent				
	CUSTOMER REQUIREMENTS	Focus Glasses	Meta RayBans	SONY Noise Cancelling Headphones
	Lightweight	5	3	3
	Balanced	4	3	3
Competitive Advantage	Affordable	5	1	3
	Comfortable	4	3	4
	Durable	3	4	5
Competitive Advantage	Discrete Appearance	4	2	2
	Effective	5	1	4
Expecter	Safe	5	4	5
Expecter	Easy to Use	4	3	4

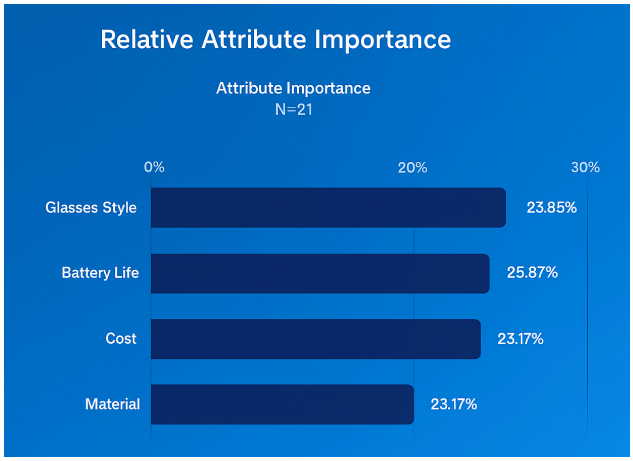
3.3.Pricing Policy

To maximize product accessibility but also maintain strong margins, we will adopt a value-based pricing mode. Rather than pricing solely on manufacturing cost, we will anchor the price to the product's perceived academic and cognitive benefit. Students already invest in productivity tools like noise-cancelling headphones, planners, and software subscriptions, which demonstrates a willingness to pay for performance-enhancing solutions. By positioning our

product as an affordable, non-pharmacological alternative that meaningfully improves focus, we can justify a retail price range of $59–$79.

3.3.1. Derived from Conjoint and other observations





From our conjoint analysis, respondents demonstrated sensitivity to price and a preference for a minimal solution for our product. Warby Parker, a major online eyewear retailer, currently offers basic glasses frames starting at $95. At our proposed value-based pricing range, our product sits comfortably alongside the lower end of the market.

3.4.Bass Model Forecasting to predict product demand

Using the Bass Model,

- Market Potential (M) = 500,000 users
- Coefficient of Innovation (p) = 0.02
- Coefficient of Imitation (q) = 0.40
- Forecast horizon = 10 years
- Year 1 cumulative adopters begins at 0 ($N_0 = 0$)

The Bass Model demand for year *t* is:

$$S(t) = (M*((p + q) ^ 2)/p) * ((exp(-(p+q)t))/(1+(q/p)*(exp(-(p+q)t))^2$$

Year	New Adopters S(t)	Cumulative N(t)	% of Market Reached
1	10,000	10,000	2%
2	14,800	24,800	4.96%
3	20,910	45,710	9.14%
4	28,557	74,267	14.85%
5	37,914	112,181	22.44%
6	48,979	161,160	32.23%
7	61,392	222,552	44.51%
8	74,366	296,918	59.38%
9	86,649	383,567	76.71%
10	96,213	479,780	95.96%

3.5.Production Costs

The following production costs have been estimated from similar competitors (Warby Parker) production costs, CustomParts calculations, and pricing from wholesale options (Alibaba) at 1,000 units.

Component	Cost Estimate
Frame (injection molded)	$6–$12
Lenses (non-prescription optical lenses)	$4–$8
LEDs (40 Hz flicker array, micro-smd)	$1.50–$3.00

Microcontroller (Attiny202, ESP32, nRF52, or similar)	$2.80–$6.50
Battery (small Li-po cell 3V)	$1.20–$3.00
Circuitry (Resistors and Capacitors) + PCB board	$3–$7
Charging port / wireless charging contact	$1–$2.50
Assembly labor	$4–$10
Quality control + testing	$2–$4
Packaging + inserts	$3–$5
Final Estimated Per-Unit Cost	**$27.5 – $55.0**

3.5.1. What manufacturing process will you use? Justify using charts from manufacturing lectures.

We will be using Injection Molding (in conjunction with polishing, grinding, and punching for hinges) to create the frames of the Focus Glasses. Referring to the charts from the manufacturing lectures, for our desired material (plastic), batch volume (mid-high), and geometry (thin wall & semi-complex), the best manufacturing process is injection molding.

3.5.2. Tooling parameters costs

Tooling cost for injection molding are dependent on material selection, cavity count and the surface finish requirements. For early production, we will use a dual-cavity steel mold for the 1,000 batch size. Cycle times for molded polymer frames are typically 30-60 secs per shot. Once automated, this will allow for minimal labor input. As demand increases, we will be able to scale tooling to 8 or 16 cavity molds and reduce the per-unit cycle time.

3.6.Cost of Goods Sold

We estimate the cost of a single unit to be ~$50 (including assembly, labor, and testing) during early production. As volume increases, material cost and processing overhead both decline due to bulk purchase agreements and increased mold utilization efficiency. The cost of goods sold is

expected to drop significantly after breakeven on tooling investment is reached. This positions the product at a healthy margin for student-friendly pricing.

3.6.1. Materials, labor, off the shelf components

PROJECT NPV $	16,294,254

Base NPV
15,000,000

Changes from Base NPV	
% of NPV	$ change
8.6%	1294254

MODEL VALUES

	first	last	base burn rate	adjusted burn rate	%Δ from base value	$Δ from base value	
Development	1	9	-30000	-30000	0.0%	0	-30
Testing	1	12	-50000	-50000	0.0%	0	-50
Tooling and Ramp-Up Costs	4	6	-90000	-90000	0.0%	0	-90
Market Introduction	7	12	-200000	-200000	0.0%	0	-200
Ongoing Marketing Costs	13	60	-100000	-100000	0.0%	0	-100
Unit Sales	7	60	100	100	0.0%	0	0
Unit Price	7	60	80	80.000	0.0%	0.00	0.130
Unit Production Cost	3	60	-55	-55.000	0.0%	0.00	-0.055
Discount Rate (per time period)	10.00%						

Set input values in shaded cells.

We anticipate the cost of materials to be around 40 dollars per pair, purchasing the frames, lens, LED, and electronics. 20 dollars per pair for labor regarding its assembly, packaging, and control. The final cost per - unit is estimated to be between 27-62 dollars. To have a net positive sales margin, we plan to mark up the overall selling price.

3.7.Net Present Value detailed analysis

Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Development	-30000	-30000	-30000	-30000	-30000	-30000	-30000	-30000	-30000	0	0	0	0	0	0	0	0	0	0	0
Testing	-50000	-50000	-50000	-50000	-50000	-50000	-50000	-50000	-50000	-50000	-50000	-50000	0	0	0	0	0	0	0	0
Tooling and Ramp-Up Costs	0	0	0	-90000	-90000	-90000	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Market Introduction	0	0	0	0	0	0	-200000	-200000	-200000	-200000	-200000	-200000	0	0	0	0	0	0	0	0
Ongoing Marketing Costs	0	0	0	0	0	0	0	0	0	0	0	0	-100000	-100000	-100000	-100000	-100000	-100000	-100000	-100000
Production Cost	0	0	0	-13750000	-16500000	-19250000	-22000000	-24750000	-24750000	-22000000	-22000000	-22000000	-22000000	-22000000	-22000000	-19250000	-19250000	-19250000	-19250000	-19250000
Product Revenues (wholesa	0	0	0	0	0	0	32000000	36000000	36000000	32000000	32000000	32000000	32000000	32000000	32000000	28000000	28000000	28000000	28000000	28000000
Unit Sales	100000	125000	0	250000	300000	350000	400000	450000	450000	400000	400000	400000	400000	400000	400000	350000	350000	350000	350000	350000
Unit Price	0	0	0	0	0	0	80.000	80.000	80.000	80.000	80.000	80.000	80.000	80.000	80.000	80.000	80.000	80.000	80.000	80.000
Unit Production Cost	0	0	-55.000	-55.000	-55.000	-55.000	-55.000	-55.000	-55.000	-55.000	-55.000	-55.000	-55.000	-55.000	-55.000	-55.000	-55.000	-55.000	-55.000	-55.000
Period Cash Flow	-80000	-80000	-80000	-13920000	-16670000	-19420000	9720000	10970000	10970000	9750000	9750000	9750000	9900000	9900000	9900000	8650000	8650000	8650000	8650000	8650000
PV Time Period 0	-72727	-66116	-60105	-9507547	-10350758	-10962084	4987897	5117586	4652351	3759047	3417316	3106650	2867677	2606979	2369981	1882492	1711356	1555779	1414344	1285767
Cumul. Disc. Cash Flow	-72727	-138843	-198948	-9706495	-20057254	-31019338	-26031441	-20913855	-16261504	-12502457	-9085141	-5978491	-3110813	-503834	1866147	3748639	5459996	7015774	8430118	9715886

We estimate a total addressable market of approximately 500,000 users. This is based on the size of our target demographic (students) and the moderate price point of our product. Using the Bass Diffusion Model, we selected a coefficient of innovation $p = 0.02$, to represent early adopters who are motivated by novelty and external marketing influences, and a coefficient of imitation $q = 0.40$, which is standard for wearables and smart devices.

Using these assumptions, we simulated product adoption over a 5-year horizon. After discounting these cash flows and subtracting initial development and launch costs, we estimated a Net Present Value (NPV) of $15,543,276, indicating strong potential commercial viability under our modeled conditions.

4. Legal Requirements

4.1. Required or Recommended certifications

Eye glasses are considered a class 1 medical device. It is also classified under the FDA Establishment Registration and device listing. Both of which require the Focus Glasses to be certified underneath them.

4.2. Potential Liability Issues

Focus glasses constantly project light into the users' eyes. If not done correctly or used correctly, this could lead to the damage of the users' retinas. The technology used does not work properly with blue light glasses, as the lens would then reflect the light back into the eye, possibly causing damage. If users do not follow directions and put in blue light glasses, they may blame the Focus glasses. Clear and precise warnings are required to prevent this.

4.2.1. Prediction of Misuse Cases

Due to the stimulation for increased alertness provided by our device, there is a realistic risk that users may intentionally abuse the glasses to prolong wakefulness during long study sessions late into the night. This lack of necessary rest can lead to circadian disruption and reduced cognitive purpose, counteracting the benefits of the product. This can also lead to long term health concerns if turned into a habit.

4.2.1.1. Failure Mode and Effect Analysis

Component	Failure Mode	Effect of Failure	Cause	Severity (S)	Occurrence (O)	Detection (D)	RPN (S×O×D)
Frame and hinges	Hinge or frame arm breaks during wear and tear	Glasses become uncomfortable or unusable due to poor fit.	Repeated flexing of loadbearing hinges; heavier arm than transitional glasses due to embedded systems.	6	4	3	72

Battery System	The battery overheats, during charging or during extended use	Burn risk and user discomfort. Potential for the device to shut down	Battery degradation, poor contact, inadequate insulation	9	3	5	135
PCB	Intermittent or no connection	Device resets or shuts off midsession or otherwise does not work as intended	Flexing of custom PCB, loose connections	5	4	4	80
Arduino Firmware?	Incorrect flicker frequency	Ineffective gamma stimulation or possibility for flicker to become visible making the product obsolete.	Bug in code?	7	4	6	168
LED	LED is too bright or visible flicker	Eye strain and potential for greater photosensitive risks	Misaligned sensor, LED age	8	3	5	120

4.3. Intellectual Property Considerations

The team reviewed patents published in the US Patent system through the Google Patents database using the following terms and search criteria:

- Focus tools
- Smart glasses for focusing
- Smart Glasses
- Invisible spectral flicker

4.3.1.Patent Landscape

We found that there are several patents related to the smart glasses from Apple visual reality to meta glasses. We also identified a range of devices spanning attention enhancing tools, phototherapeutic applications, and myopia prevention technologies. Below we go in depth on these patents to understand what has been done and what is the gap in intellectual property.

US20230194891A1: Monocoque smart glasses temple pre-form

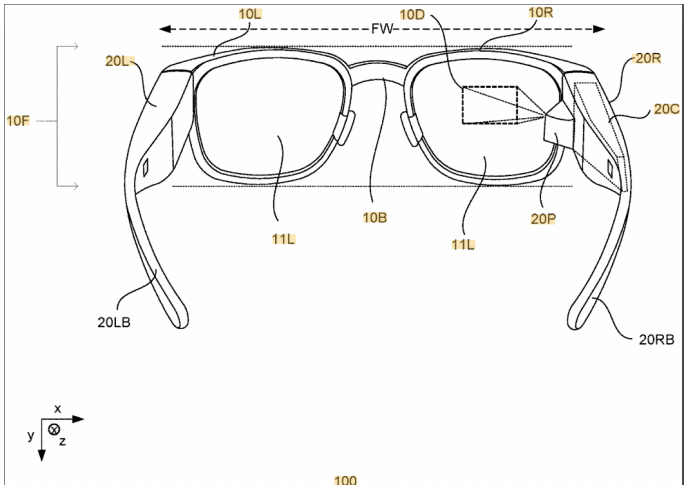
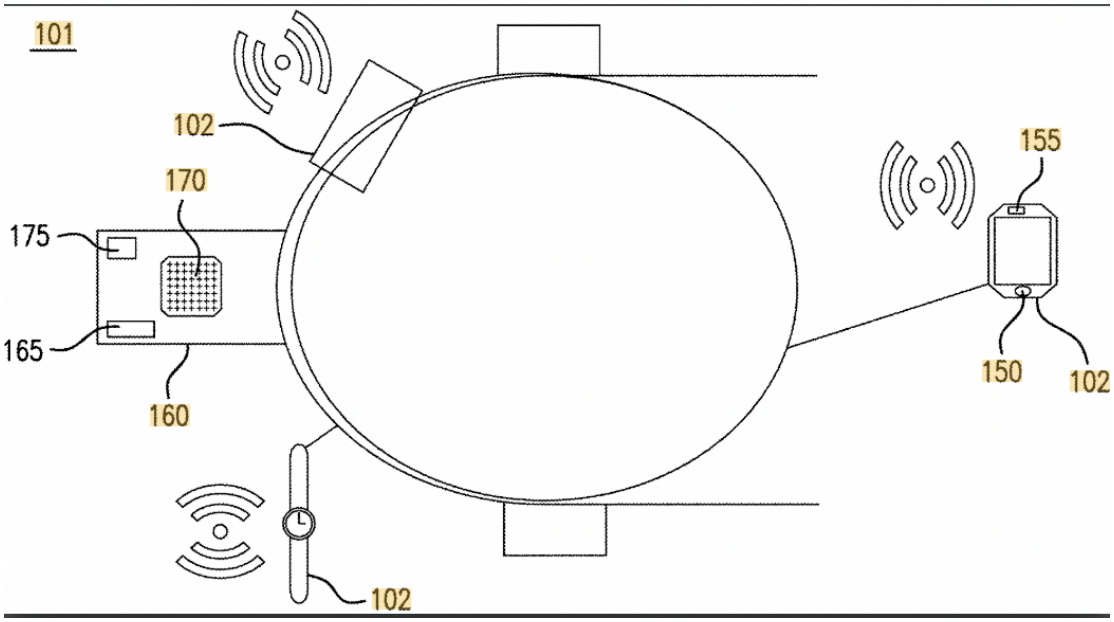


Figure 1: **US20230194891A1**

Patent US20230194891A1 describes the method of manufacturing smart glasses where the electronics are embedded on the glasses arm [5]. Figure one represents the electronics embedded and how they project onto the lenses. This device consists of batteries, sensors, processors, wires, LEDs, speakers or haptics. This patent focuses on the method to store electrical components for smart glasses but does not propose a novel technique for focus enhancement.

US11544036B2: Multi-frequency sensing system with improved smart glasses and devices



Patent US11544036B2 describes a system for smart glasses or other devices that can sense different types of signals at different frequencies [6]. This device detects different signals and allows the user to adjust environmental conditions from light, sound and exposure. The goal of this technology is to adjust potentially harmful signals to improve safety, comfort, or environmental awareness. This patent does not include any focus enhancement technology.

JP7096369B2: Smart glasses, eye trajectory tracking methods, devices and storage media

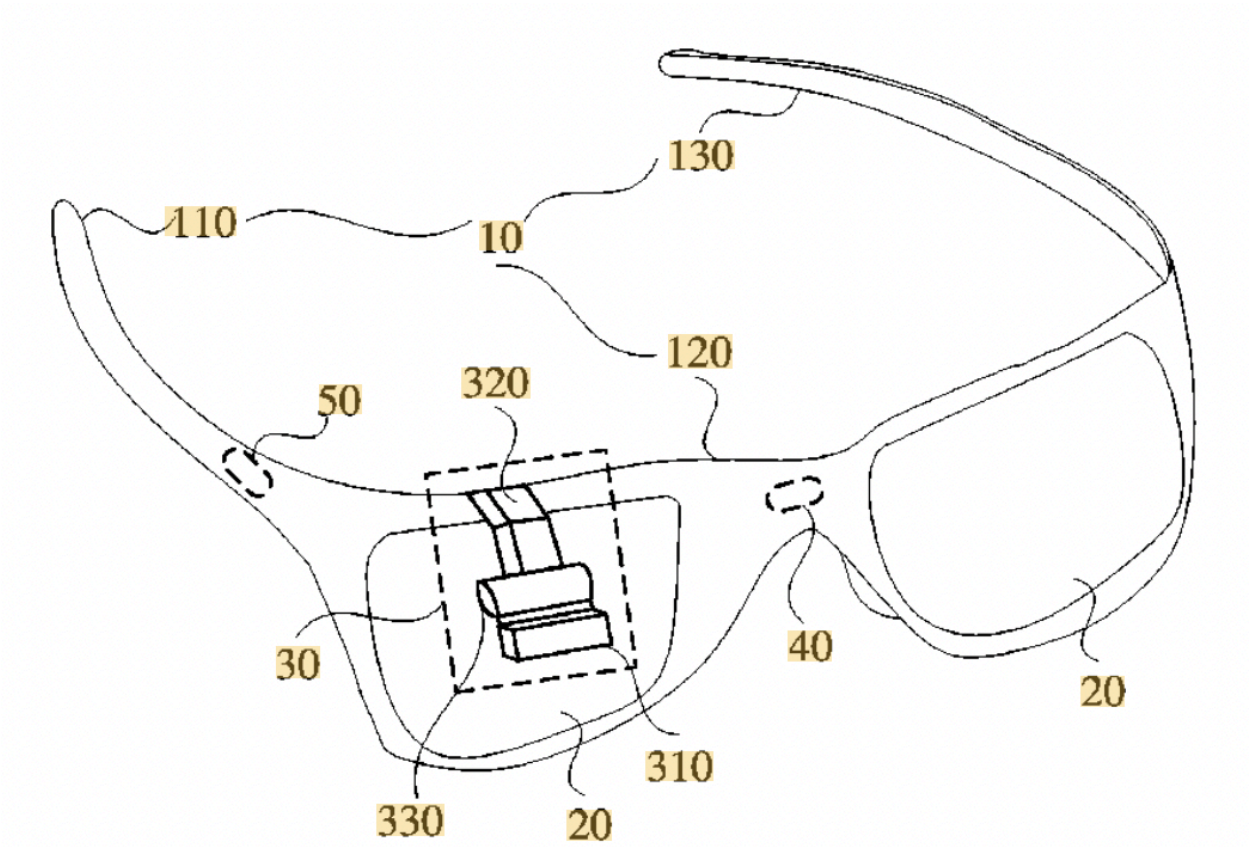
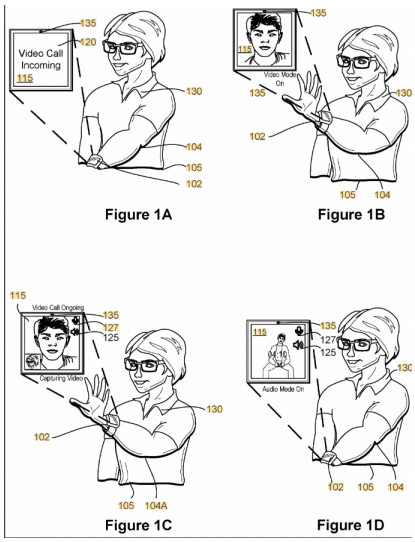


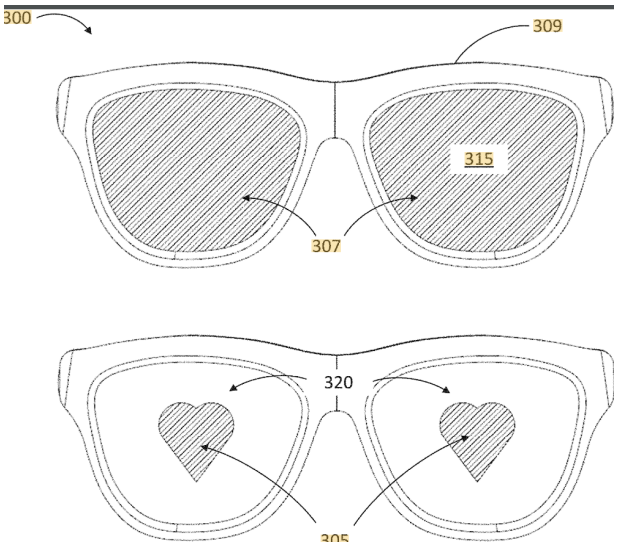
图 1

JPS5247093B2 is an expired patent that describes a pair of glasses for eyeball movement tracking [7]. It uses a system that makes sure that the alignment of the camera is adjusted properly for optimal eye tracking. While this device does not necessarily compare to ours it is a technology that we could eventually integrate to detect loss of attention.

US20230328168A1: Head-worn wearable devices for automatically ceasing the capture of video data, and methods of use thereof

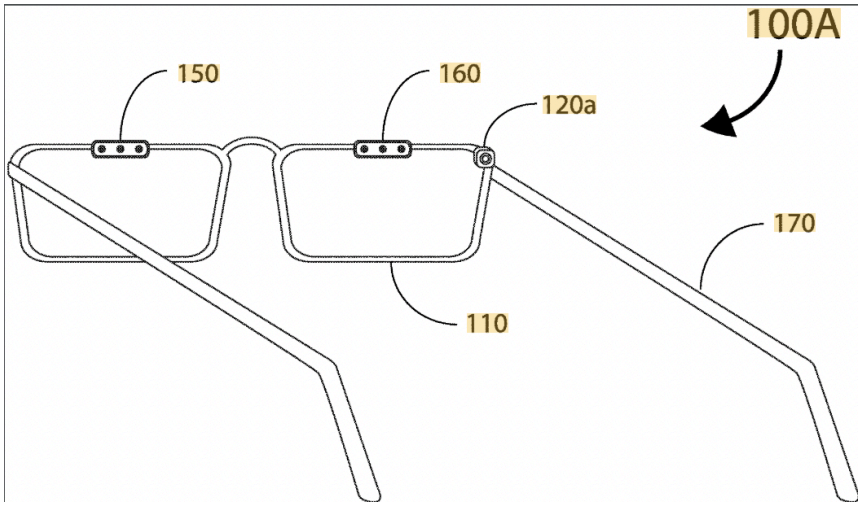


US20230316672A1 Smart glasses with enhanced optical structures for augmented reality applications



Patents **US20230328168A1** and **US20230316672A1** are assigned to Meta Technologies and describe both the optical technology used in the lens and the wristband to control what is displayed on the glasses [8], [9]. Both of them are utility patents and how they can achieve the display and control of the display. Although these glasses could achieve some sort of invisible spectral flicker, focus glasses will not be smart glasses therefore their utility is different.

US11000186B2: Systems and methods for retarding myopia progression



We found patent US11000186B2 to be of interest although the utility of this device has a very different use from our design idea [10]. This device consists of a sensor that measures pupillary response and then simulates sunlight to illuminate the eyes to prevent myopia progression.

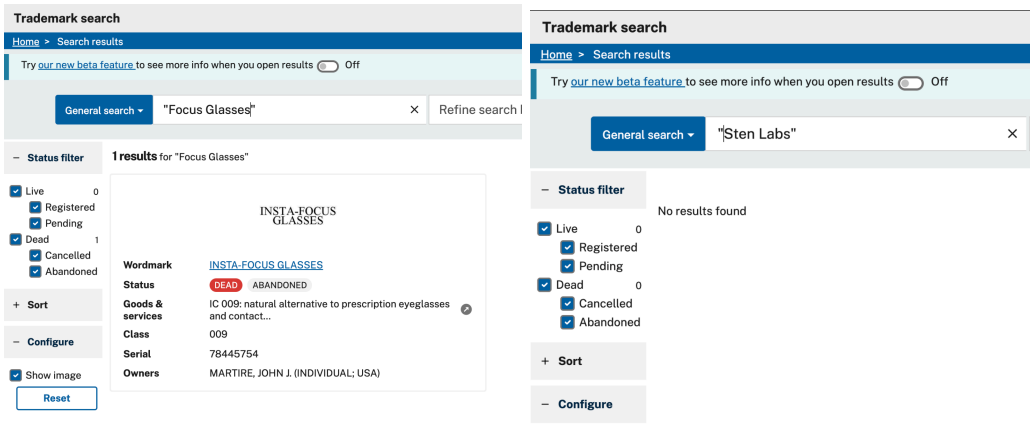
5.3.2.Pursue Utility, Design patents? Why?

For Focus glasses we plan to pursue a utility patent since the invisible spectral flicker to enhance attention is the novelty in this product. Unlike other smart glasses technologies where their novelty lies on the display, control and overall use, we plan to use light modulation to enhance cognitive attention.

5.3.3.Trade secrets? Why?

The Focus Glasses may have certain trade secrets regarding its innovative design. The circuit set up and its code are considered trade secrets. Without it, the device would not be able to function and the code is unique and specific to the design. If leaked, competitors would gain an advantage, so it is viable to consider both of these aspects as trade secrets.

5.3.4.Trademark? Describe

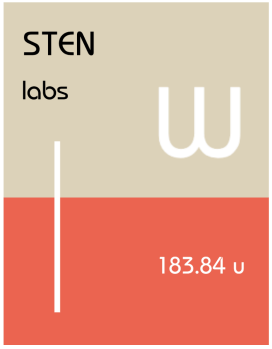


After searching in the USPTO Trademark search we found that the name Sten Labs has not been yet trademarked therefore we can use this once we develop our company. Similarly the product name Focus Glasses has not been used. There was a trademark that was abandoned for the name “Insta-Focus Glasses”. On the other hand our logo was developed in house so we can copyright it.

The Logo and name of the device can be trademarked. As both revolve specifically to this device and are unique to describe not only the functionality but also the brand

5.3.4.1. Team name and logo

TeamName: StenLabs



5.3.4.2. Other trademark opportunities?

Since the device’s utility is unique, it would also open opportunities for trademarks and the development of individual product logos that people can easily recognize.

5. Sources

5.1. Bibliography

[1] M. P. Agger *et al.*, “Novel Invisible Spectral Flicker Induces 40 Hz Neural Entrainment with Similar Spatial Distribution as 40 Hz Stroboscopic Light,” *J Alzheimers Dis*, vol. 88, no. 1, pp. 335–344, doi: 10.3233/JAD-220081.

[2] “Light-based gamma entrainment with novel invisible spectral flicker stimuli | Scientific Reports.” Accessed: Nov. 25, 2025. [Online]. Available: https://www.nature.com/articles/s41598-024-75448-4

[3] “40 Hz Audiovisual Stimulation Improves Sustained Attention and Related Brain Oscillations - PubMed.” Accessed: Dec. 10, 2025. [Online]. Available: https://pubmed-ncbi-nlm-nih-gov.ezproxy.neu.edu/40909555/

[4] T. J. Doty *et al.*, “Limited Efficacy of Caffeine and Recovery Costs During and Following 5 Days of Chronic Sleep Restriction,” *Sleep*, vol. 40, no. 12, Dec. 2017, doi: 10.1093/sleep/zsx171.

[5] J. Yang, J. Moore, E. A. Bokides, and J. N. Castro, “Monocoque smart glasses temple pre-form,” US20230194891A1, June 22, 2023 Accessed: Nov. 25, 2025. [Online]. Available: https://patents.google.com/patent/US20230194891A1/en?oq=US20230194891A1

[6] L. Denton, “Multi-frequency sensing system with improved smart glasses and devices,” US11544036B2, Jan. 03, 2023 Accessed: Nov. 25, 2025. [Online]. Available: https://patents.google.com/patent/US11544036B2/en?oq=US11544036B2

[7] 秦林▲嬋▼, 琳 ▲劉▼, and 黄通兵, “スマートグラス、眼球軌跡の追跡方法、装置及び記憶媒体,” JP7096369B2, July 05, 2022 Accessed: Nov. 25, 2025. [Online]. Available: https://patents.google.com/patent/JP7096369B2/en?oq=JP7096369B2

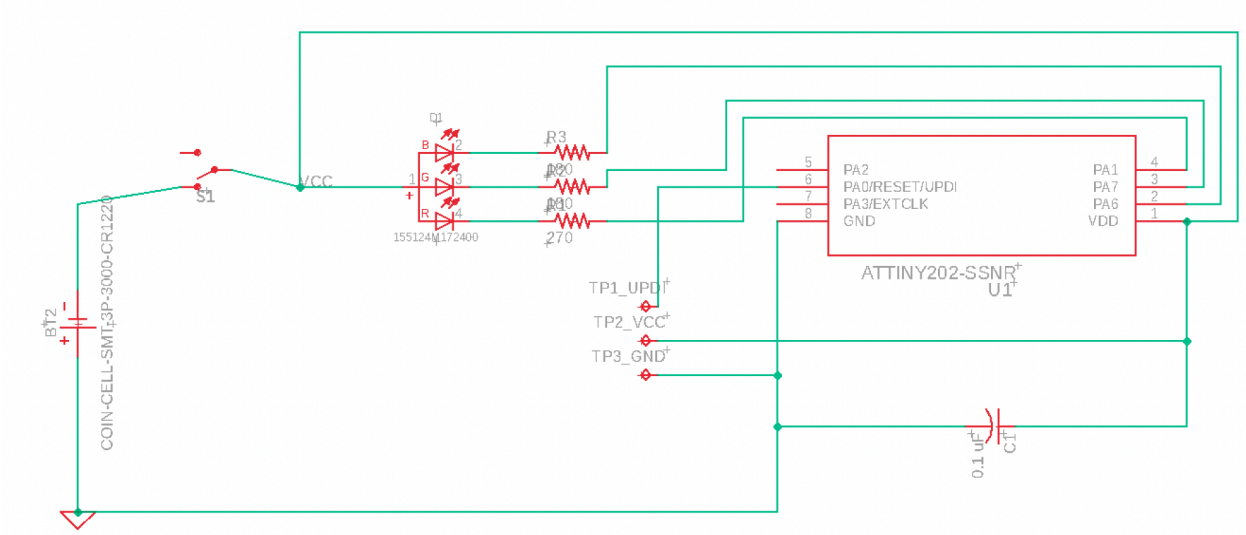
[8] B. D. Silverstein and K. C. Kelly, “Smart glasses with enhanced optical structures for augmented reality applications,” US20230316672A1, Oct. 05, 2023 Accessed: Nov. 25, 2025. [Online]. Available: https://patents.google.com/patent/US20230316672A1/en?oq=US20230316672A1

[9] W. Huang, D. S. Woodland, H. Hobeika, and B. N. Bethurum, “Head-worn wearable devices for automatically ceasing the capture of video data, and methods of use thereof,” US20230328168A1, Oct. 12, 2023 Accessed: Nov. 25, 2025. [Online]. Available: https://patents.google.com/patent/US20230328168A1/en?oq=US20230328168A1

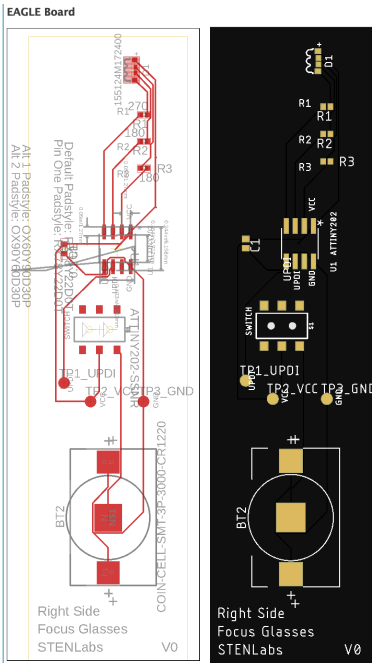
[10] B. J. Linder, “Systems and methods for retarding myopia progression,” US11000186B2, May 11, 2021 Accessed: Nov. 25, 2025. [Online]. Available: https://patents.google.com/patent/US11000186B2/en?oq=US11000186B2

5.2. Appendices

A. **HOQ**
B. **NPV Spreadsheets**
C. **Circuit Design Or PCB**



D. PCB Board



E. Code for PCB Board

```
const uint8_t PIN_RED   = PIN_PA1;
const uint8_t PIN_GREEN = PIN_PA7;
const uint8_t PIN_BLUE  = PIN_PA6;

// NOTE: You are using a **common-anode RGB LED** on your PCB
// → LED ON = LOW
// → LED OFF = HIGH

const int PERIOD_US = 33333;   // 1 / 30 Hz = 0.033333 seconds
const int HALF_PERIOD_US = PERIOD_US / 2;   // ~16.6 ms ON, ~16.6 ms ON

void setup() {
  pinMode(PIN_RED,   OUTPUT);
  pinMode(PIN_GREEN, OUTPUT);
  pinMode(PIN_BLUE,  OUTPUT);

  // turn everything OFF
  digitalWrite(PIN_RED,   HIGH);
  digitalWrite(PIN_GREEN, HIGH);
  digitalWrite(PIN_BLUE,  HIGH);
}

void loop() {

  // --- YELLOW (RED + GREEN) ---
  digitalWrite(PIN_RED,   LOW);   // turn ON
  digitalWrite(PIN_GREEN, LOW);
  digitalWrite(PIN_BLUE,  HIGH);  // blue OFF
  delayMicroseconds(HALF_PERIOD_US);

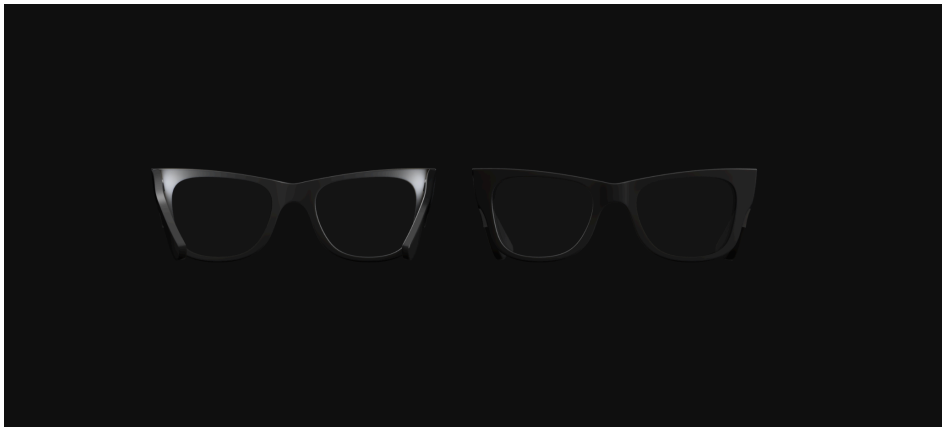
  // --- WHITE (R + G + B) ---
  digitalWrite(PIN_RED,   LOW);
  digitalWrite(PIN_GREEN, LOW);
  digitalWrite(PIN_BLUE,  LOW);
  delayMicroseconds(HALF_PERIOD_US);

}
```

Done uploading.

F. Product Gallery







```
const uint8_t PIN_RED   = PIN_PA1;
const uint8_t PIN_GREEN = PIN_PA7;
const uint8_t PIN_BLUE  = PIN_PA6;
```

```
// NOTE: You are using a **common-anode RGB LED** on your PCB
// → LED ON = LOW
// → LED OFF = HIGH

const int PERIOD_US = 33333;   // 1 / 30 Hz = 0.033333 seconds
const int HALF_PERIOD_US = PERIOD_US / 2;   // ~16.6 ms ON, ~16.6 ms ON

void setup() {
  pinMode(PIN_RED,   OUTPUT);
  pinMode(PIN_GREEN, OUTPUT);
  pinMode(PIN_BLUE,  OUTPUT);

  // turn everything OFF
  digitalWrite(PIN_RED,   HIGH);
  digitalWrite(PIN_GREEN, HIGH);
  digitalWrite(PIN_BLUE,  HIGH);
}

void loop() {

  // --- YELLOW (RED + GREEN) ---
  digitalWrite(PIN_RED,   LOW);   // turn ON
  digitalWrite(PIN_GREEN, LOW);
  digitalWrite(PIN_BLUE,  HIGH);  // blue OFF
  delayMicroseconds(HALF_PERIOD_US);

  // --- WHITE (R + G + B) ---
  digitalWrite(PIN_RED,   LOW);
  digitalWrite(PIN_GREEN, LOW);
  digitalWrite(PIN_BLUE,  LOW);
  delayMicroseconds(HALF_PERIOD_US);

}
```

BACKUP

```
// --- Pin mapping (ATTiny202 + megaTinyCore) ---
const uint8_t PIN_RED   = PIN_PA3;
const uint8_t PIN_GREEN = PIN_PA7;
const uint8_t PIN_BLUE  = PIN_PA6;

// --- Brightness levels (0–255) ---
const uint8_t WHITE_HIGH = 120;   // brighter white
const uint8_t WHITE_LOW  = 40;    // dimmer "off-white"

// --- Flicker settings ---
const uint32_t FLICKER_HZ       = 40;
const uint32_t PERIOD_US        = 1000000UL / FLICKER_HZ;  // 25,000 µs
const uint32_t HALF_PERIOD_US   = PERIOD_US / 2;           // 12,500 µs

bool stateHigh = false;
uint32_t lastToggleTime = 0;

void setup() {
pinMode(PIN_RED,   OUTPUT);
pinMode(PIN_GREEN, OUTPUT);
pinMode(PIN_BLUE,  OUTPUT);

// Start in low/off-white state
analogWrite(PIN_RED,   WHITE_LOW);
analogWrite(PIN_GREEN, WHITE_LOW);
analogWrite(PIN_BLUE,  WHITE_LOW);
}

void loop() {
uint32_t now = micros();

// Toggle every half period -> full cycle is 40 Hz
if (now - lastToggleTime >= HALF_PERIOD_US) {
lastToggleTime = now;
stateHigh = !stateHigh;

if (stateHigh) {
// "White" (brighter)
analogWrite(PIN_RED,   WHITE_HIGH);
analogWrite(PIN_GREEN, WHITE_HIGH);
```

```
//analogWrite(PIN_BLUE,  WHITE_HIGH);
} else {
// "Off-white" (dimmer)
analogWrite(PIN_RED,   WHITE_LOW);
analogWrite(PIN_GREEN, WHITE_LOW);
//analogWrite(PIN_BLUE,  WHITE_LOW);
}
}
}
```