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Lightweighting for a Low-Carbon Ride

Interreg
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EDU-CIRC

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DOCUMENT APPROVAL

Name	Organization	Role	Action	Date
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1. Introduction

This session explores how reducing a vehicle's weight can rapidly lower CO_2 emissions and extend electric vehicle (EV) range. Through a focused presentation, tactile material exploration (steel, aluminium, magnesium, CFRP), and a guided calculation activity, participants gain an understanding of how density, strength, and embodied energy relate to sustainability in automotive design. A closing discussion links these learnings to policy trends and career opportunities in engineering and design.

1.1 Learning Objectives

- Define light weighting and describe its sustainability drivers: energy efficiency, emissions reduction, and resource conservation.
- Compare specific strength, stiffness, and embodied carbon of four automotive materials.
- Calculate the life-cycle CO_2 benefit of removing 200 kg from a midsize vehicle.
- Identify design strategies such as material substitution and section-modulus optimization.

1.2 Required Knowledge

- Basic physics and math (algebra-level)
- General interest in automotive design or environmental topics

2. Workshop Structure

Table 1: Workshop structure

Phase	Duration	Activities	Purpose	Materials
Opening	10 min	Welcome, introductions, icebreakers	Set tone and expectations	Name tags, agenda, whiteboard, markers
Context Setting	10-15 min	Presentation: What is light weighting and why it matters	Introduce core concepts	Slides, projector
Main Content	50 min	Vehicle Light weighting Challenge	Apply knowledge collaboratively	Material cards, Requirements table, Worksheets, Calculator
Wrap-up	15 min	Announce winner and summarize topic once more	Consolidate learning	/

2.1 Workshop Agenda

Table 2: Workshop agenda

Time	Activity	Format	Duration	Materials	Facilitator Notes
0:00-0:10	Welcome & Introductions	Group discussion	10 min	Whiteboard	Ask: Where car does weight matter most?
0:10-0:25	Light weighting Overview	Presentation	15 min	Slides	Cover definitions, impacts, and examples
0:25-0:55	Vehicle Light weighting Challenge	Group Activity	30 min	Samples, worksheets	Teams compare and compute
0:55-1:05	Break	Networking	10 min	Refreshments	Encourage informal connections
1:05-1:25	Team pitches	Presentation	20 min	Slides, real parts if available	Show how much weight, fuel and CO2 saved
1:25-1:35	Wrap-Up & Q&A	Group discussion	15 min	Reflect and consolidate learning	Discuss different materials and final results

2.2 Required Equipment

Table 3: Required Equipment

Category	Item	Quantity	Purpose	Alternative Options
Technology	Projector/screen	1 set	Presentations	Large monitor, TV Screen
Materials	Material option cards	1 set/group	Hands-on comparison	Photos with specs if samples not available
Materials	Worksheets	1 set/group	Calculations / changes	Digital version
Materials	Requirements Table	1 set/group	Hands-on Comparison	Digital version
Supplies	Markers/pens, calculator	1 per group	Perform fuel and CO_2 calculations	Digital tools, tablets, Smartphone calculators
Documentation	Worksheets	1 set per group	Material, data, formulas	Digital printed handouts

2.3 Evaluation Framework

Table 4: Workshop Evaluation

Evaluation Type	Timing	Method	Key Metrics	Follow-up Actions
Immediate	End of workshop	Feedback forms	Satisfaction, concept clarity, material engagement, CO_2 calc confidence	Immediate improvements

Short-term	1-2 weeks later	Email survey	Interest in mobility design, curiosity about materials	Share resources on materials and careers
Long-term	3-6 months later	Interview/survey	Retention, awareness of policy connections	Plan follow-up sessions

3. Detailed Explanation

3.1 Opening

0:00-0:10

- **Organizing the room**
- **Brief information about Edu-Circ**
- **Opening speech:**

“Welcome! Today we’ll connect sustainability with practical engineering. Our focus: how reducing vehicle mass lowers fuel use and CO_2 without breaking constraints on strength, corrosion, and cost. You’ll work in teams to redesign a 2000 kg baseline vehicle and target ≥200 kg mass reduction. Let’s start by listing what drives fuel consumption—and see why mass is a powerful lever.”

3.2 Presentation

0:10-0:25

Slide 1: Light weighting for a Low-Carbon Ride

Speaker Notes: “Welcome, everyone. Today we’ll connect sustainability with practical engineering—specifically how reducing vehicle mass lowers fuel consumption and CO_2. We’ll move from the big picture to a hands-on workshop where you’ll redesign a baseline vehicle using provided data and constraints. Let’s start with why sustainability matters.**”**

Slide 2: Why Sustainability matters?

Speaker Notes:

“1. Our population and living standards keep rising, which increases demand for energy, materials, water, and land. That pressure challenges how we design and use products. Sustainability isn’t just ethical; it’s a design constraint that affects cost, risk, and resilience.

Those needs have historically been met by fossil fuels—let’s look at that challenge next.

2. Climate change, air pollution, and biodiversity loss are outcomes of how we produce and consume. Engineering choices—materials, processes, and product use—directly influence these impacts. Small improvements at scale can yield large benefits.

So what’s the engineering role in changing that trajectory?

3. Our job is to deliver function with less energy and fewer resources over the full lifecycle—manufacture, use, and end-of-life. That means efficiency, durability, reparability, and circularity. Today we’ll focus on one powerful lever in transport: mass reduction.**”**

Slide 3: The Challenge with Fossil Fuels

Speaker Notes: “Coal, oil, and natural gas built modern industry and mobility, but at the cost of emissions and pollution. Because transport heavily depends on these fuels, every liter saved—or avoided—matters. Cutting energy use via lighter vehicles reduces both operating cost and carbon “

Slide 4: Sustainability of Natural Sources

Speaker Notes:

“1. Renewables like solar, wind, hydro, and sustainable biomass reduce operational emissions. But energy is only half the story—how efficiently we use materials determines total footprint. Efficient products need less energy and fewer raw inputs over time.

2. Using the right amount of the right material—preferably recycled or recyclable—lowers embodied energy and risk. Smart design can deliver the same performance with less material, which also reduces the energy needed to move the product during use.

3. Design for reuse, repair, and recycling keeps materials in loop and reduces virgin extraction. For vehicles, that means choosing materials that meet performance needs today and have a viable end-of-life pathway tomorrow.”

Slide 5: Leading Source of Emissions

Speaker Notes: “Transport is a major contributor to greenhouse gases in many regions—often more than a quarter. Improving efficiency per kilometer is essential, especially while the fleet transitions to lower-carbon energy sources.”

Slide 6: Why Vehicle Mass Matters?

Speaker Notes: “Physics is simple here: more mass requires more energy to accelerate and climb, and more braking energy is wasted as heat. Lighter vehicles typically consume less fuel or, for EVs, deliver more range for the same battery.”

Slide 7: Vehicle Mass and Fuel Consumption

Speaker Notes: "A useful rule of thumb is that for every 1% reduction in mass, there is a 0.6–0.7% reduction in fuel usage, provided that size and performance remain constant. Additionally, mass reduction lowers brake and tire wear, providing secondary environmental and cost benefits."

Slide 8: Strategies for Reducing Vehicle Mass
Speaker Notes: "

- So how do we actually achieve mass reduction?

1. Substitute where it pays: AHSS for thinner, stronger sections; aluminum for large body or chassis parts; and composites in selective, high-benefit areas. Always check trade-offs—cost, corrosion protection, repairability, and recyclability.
2. Use the geometry: optimize sections, remove non-load-bearing mass, and integrate functions. Digital tools help cut grams while meeting stiffness, strength, and crash requirements. The best solution often combines smarter shapes with selective materials.
3. Component integration cuts joints, fasteners, and overlapping material, reducing mass and assembly time. Validate manufacturability, service access, crash repair, and total cost before committing.

Slide 9: WORKSHOP

Speaker Notes: "You'll start from a 2000 kg baseline vehicle. Your goals: save ≥200 kg, meet all subsystem requirements, and do it with minimum cost."

Slide 10: What you will use?

Speaker Notes: "Use the Material Option Cards, the Requirements Table, the Ashby chart provided, and the worksheet to track mass, cost, and compliance."

Slide 11: Evaluation Process

Speaker Notes: Before presentations, hand in your worksheet. The jury will verify requirements, review your calculations, and grade clarity of reasoning. We'll announce the winning team at the end.

3.3 Activity Vehicle Light weighting Challenge

0:25 – 0:55

Goal: Redesign the baseline vehicle to achieve at least 200 kg mass reduction while meeting all subsystem requirements, minimizing cost, and calculating fuel & CO_2 savings. Complete the provided worksheet.

Instructions (project these):

- Start mass: 1800 kg. Target: ≤ 1600 kg final mass.
- Each group will choose one lightweight material from the Material Option Cards and apply it to eligible subsystems to compare results across groups.
- For each subsystem: record Chosen Material, Cost per kg, Yield Strength, Corrosion Rating, Weight Factor, Meets Requirements? (Y/N), New Mass (kg), Mass Saved (kg), Cost Change (€), and Notes.
- Use the Material Option Cards and Requirements Table to verify compliance.
- Replace materials only where strength and corrosion requirements are met.
- After redesign: compute total mass saved (Δm), total redesigned cost (€), fuel saved (L), and CO_2 saved (kg CO_2-eq).
- Fill in Part 1, Part 2, and Part 3 of your worksheet.

Facilitator tips:

- Circulate among teams; first ask: “Which subsystems offer you the largest potential savings for your chosen material?”
- Remind teams:
  - Check minimum yield strength and corrosion rating before choosing.
  - Don’t forget cost calculations when selecting lightweight materials.
- Encourage discussion on trade-offs between cost, performance, and savings.
- At the end, compare results across all groups to see which material achieved the best balance of weight savings and cost efficiency.

3.4 Break

0:55 -1:05

Instructions for Organizers:

- Inform students where they can find beverages and snacks during the break.
- While students are on break, prepare the room for the upcoming presentations.

3.5 Team pitches

1:05-1:25

Students Presents their re-designed vehicle, meanwhile juty checks their worksheets.

3.6 Wrap-Up & Q&A

1:25-1:40

Discussion prompts (2–3 quick questions):

- “Which material delivered the best kg saved per €?”
- “What constraint limited you most—strength, corrosion, or cost?”
- “Where would you look next for additional savings?”
- Close: Discuss different materials, highlight one best practice, collect feedback cards.