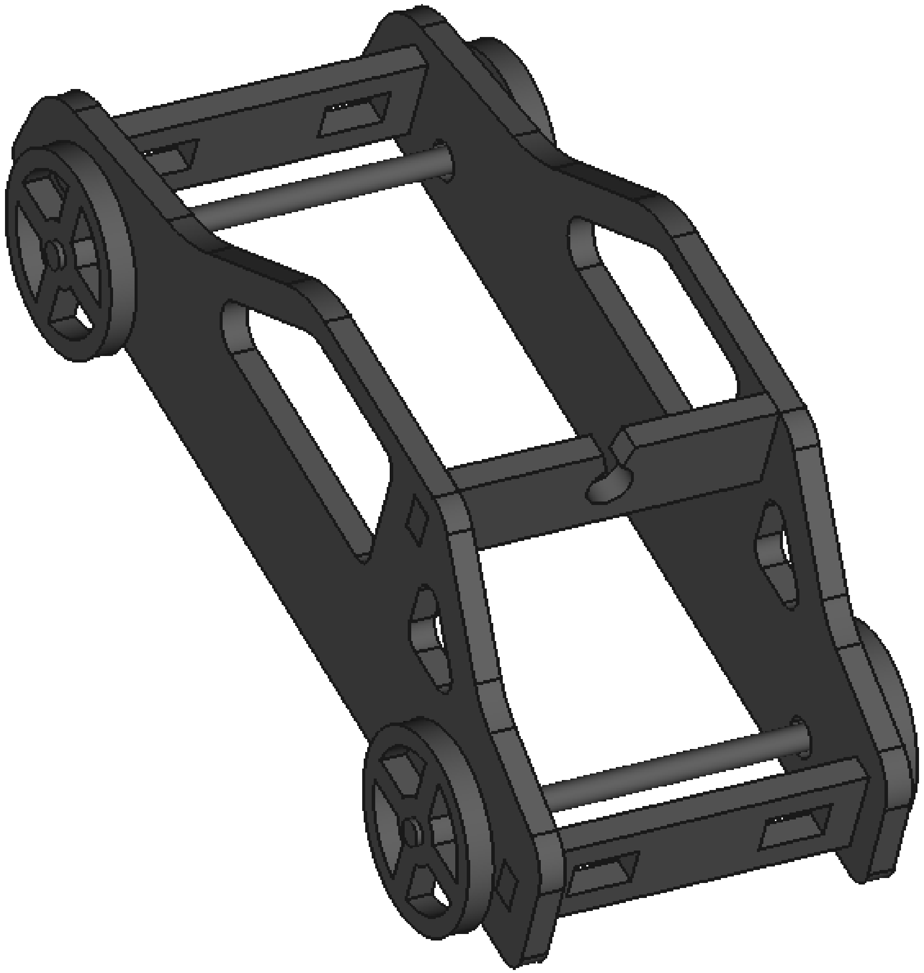
Good Practices for STEM Education Projects

Hakki Ilker KOSTUR, PhD.
Baskent University
Faculty of Education
Ankara, Turkiye



STEM Education Talks
Day 2
16/12/2022, Friday, 19:00

Erasmus+ KA210 Project:
Strong Schools with 21st Century Skills for Sustainable Education in Europe

STEM PD
stempd.net

ICSE
International Centre for STEM Education

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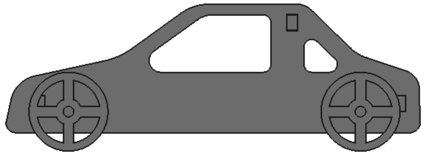
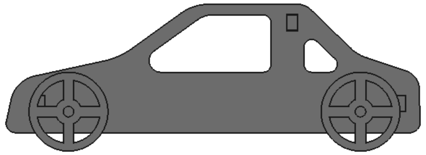


Presenter

- Dr. Hakki Ilker Kostur
- Assistant Professor at Baskent University, Faculty of Education in Ankara, Turkey

- Bachelor's and PhD. education in Science Education

- Research interests:
  - STEM education approach, history of science in science education, experiment and project design, development of science process skills and soft skills, learning outside of classroom.



STEM PD

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The expectations of:

Countries,
21st century,
Business World

Austin Achieve Public Schools 3.4 ★

2023-24 Science Teacher, High School

Austin, TX

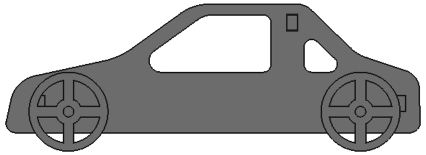
- Ability to interpret data
- Thorough understanding of school operations
- Strong organizational, communication, and interpersonal skills
- Ability to coordinate campus wide initiatives

- Work cooperatively with special education teachers to modify curricula as needed for special education students according to guidelines established in Individual Education Plans (IEP).
- Work with other members of staff to determine instructional goals, objectives, and methods according to district requirements.
- Plan and supervise assignments of teacher aide(s) and volunteer(s).
- Use technology to strengthen the teaching/learning process.
- Help students analyze and improve study methods and habits.
- Conduct ongoing assessment of student achievement through formal and informal testing.
- Assume responsibility for extracurricular activities as assigned. Sponsor outside activities approved by the campus principal.
- Be a positive role model for students, support mission of school district.
- Create classroom environment conducive to learning and appropriate for the physical, social, and emotional development of students.

Cooperation skills
Lifetime learner
Communication skills
Innovative and productive
Technological skills

These can be seen in any job postings in 21st century.

Bonus question: Can you assess these expectations in a job interview?

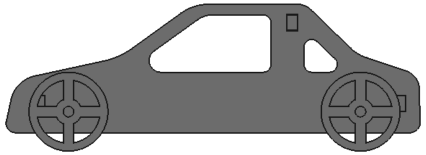


The expectations of:
Countries, 21st century, Business World

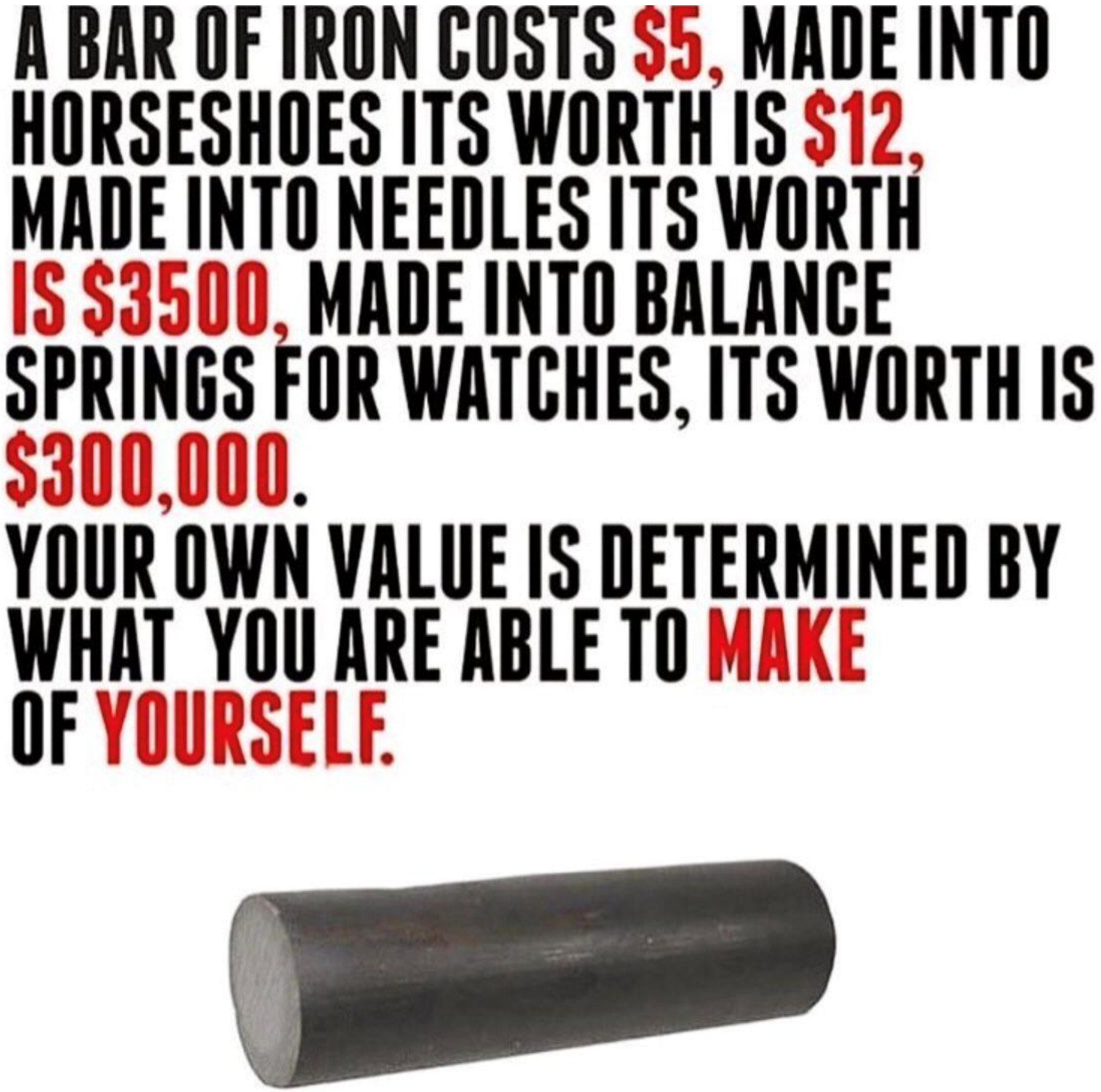
- Educational aims are shaped through the needs of countries as they consider the needs of the business world of the century in order to compete with other countries.

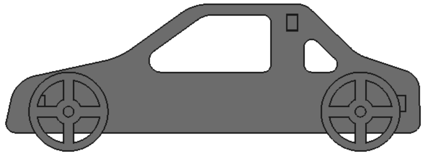
- Countries need people who add value to jobs, products, ideas, individuals.

- As educators, we see this effort in the science curricula which are equipped with a lot of affective and cognitive skills which serve to develop scientific literacy.



Adding value in one picture





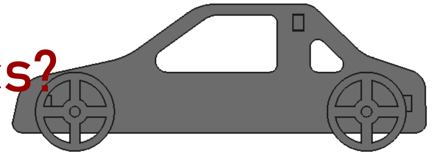
The expectations of:

Countries, 21st century, Business World

- Scientific literate people:
  - Basic knowledge of scientific facts,
  - Soft skills such as problem solving, inquiry, critical and analytical thinking, cooperation, teamwork, communication, creativity, entrepreneurship, lifetime learning, engineering skills, product development…
  - Experience in science process skills such as observation, prediction, inferring, knowledge of variables, creating hypotheses, data analysis, interpretation…
  - Awareness of sustainability; philosophy, history and nature of science, socio-scientific issues…
  - Affective development such as positive motivation and attitudes towards science, respect to science…

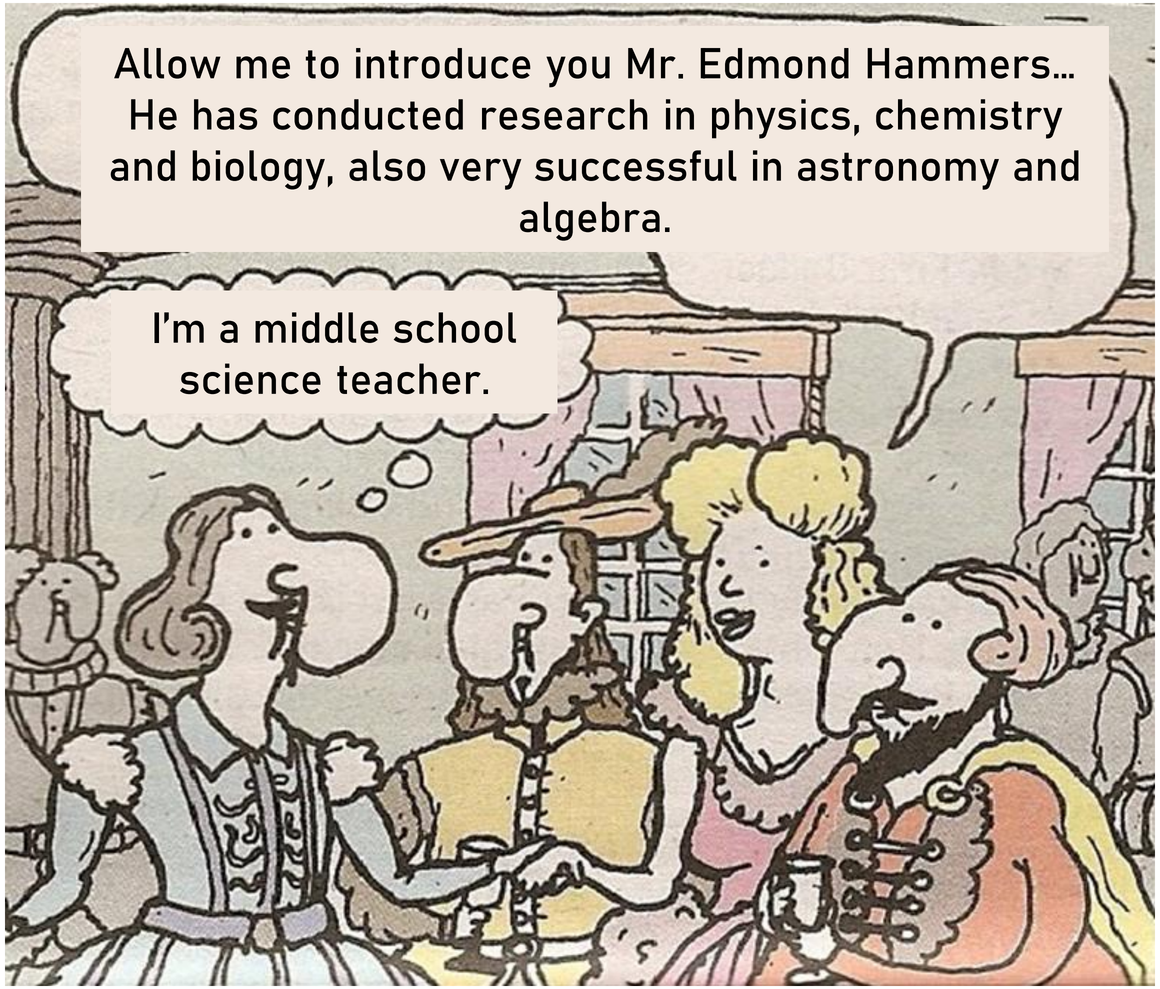
- Question:

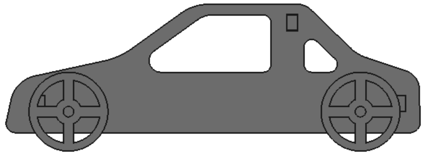
How much scientific literacy can we produce by «teaching» the science topics?



A science teacher

has to master all of these qualifications in order to transfer them to the students.



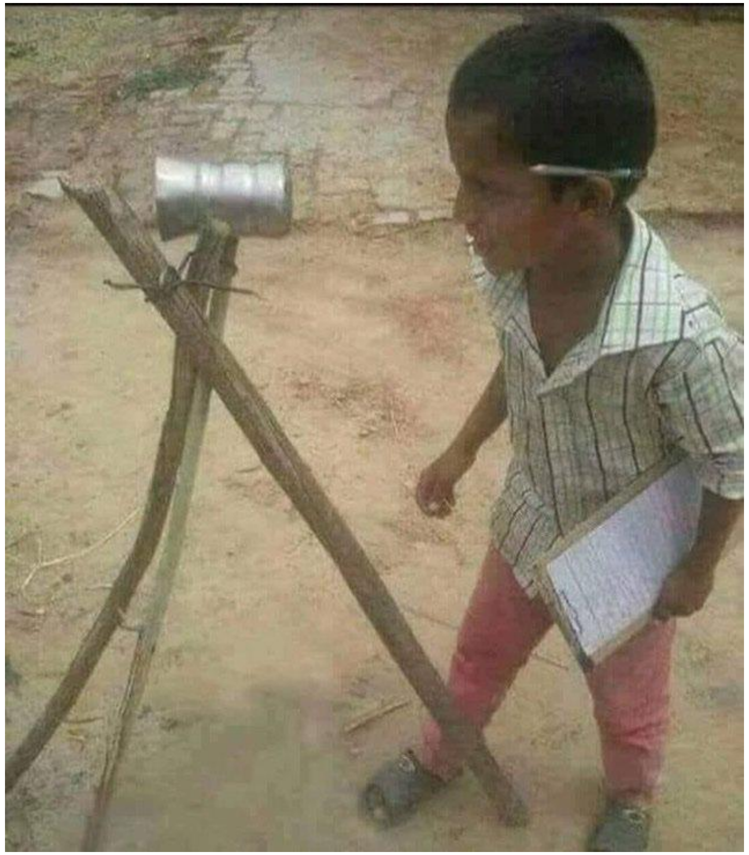


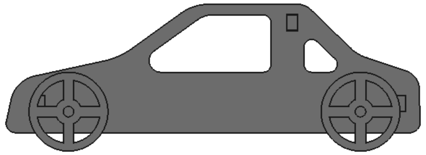
Creativity, Problem solving, Inquiry

Hey guys I was at the beach and I found this little fella
Hes pretty, does anyone know what this is?

^ Toxicity

The blue-ringed octopus, despite its small size, carries enough venom to kill twenty-six adult humans within minutes. Their bites are tiny and often painless, with many victims not realizing they have been envenomated until respiratory depression and paralysis start to set in.[8] No blue-ringed octopus antivenom is available yet, making it one of the deadliest reef inhabitants in the ocean.

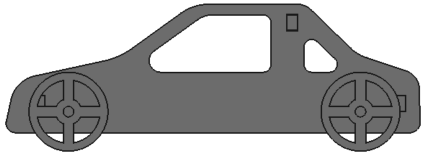




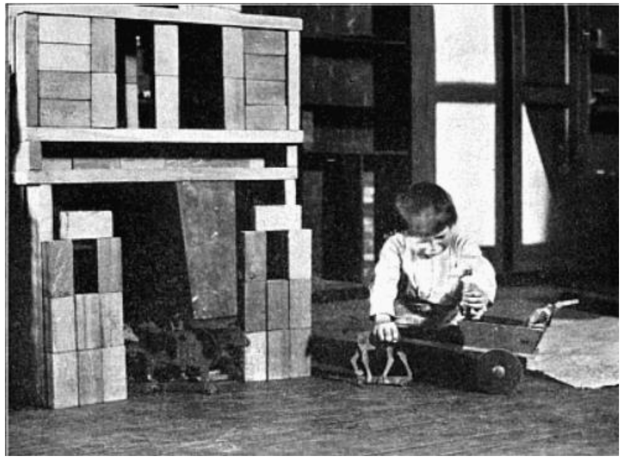
How much scientific literacy can we produce by «teaching» the science topics?

- Answer: None.

- This is the point STEM education came to rescue as working on successfully managed collaborative interdisciplinary material/product development projects need and can develop everything connected to scientific literacy.



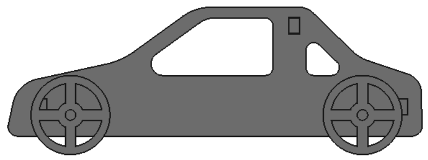
History of STEM: A very long journey



- Friedrich Fröbel (1782-1852): Fröbel's Gifts, Kindergarten.
- Caroline Pratt (1867-1954): Do-With-Toys = Unit Blocks.
- Patty Hill (1868-1946): Patty Hill Blocks
- Frank Hornby (1863-1936): Meccano construction sets.
- Ole Kirk Kristiansen (1891-1958): LEGO.
- Sputnik Crisis and post effects (1960s): Birth of constructive approaches.
- 21st century: Birth of STEM oriented projects and product/material design.

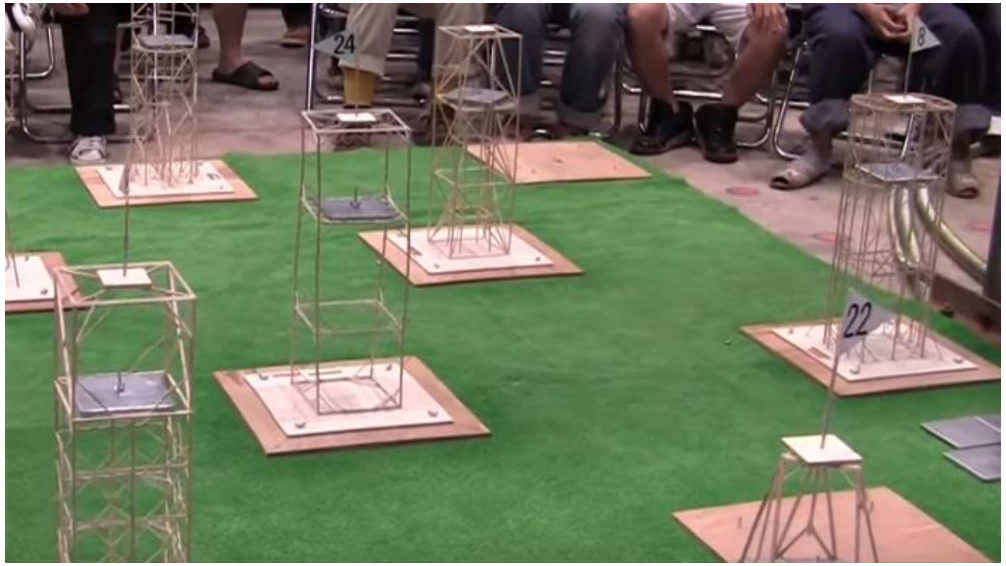
Good practices: STEM lab. as the R&D lab.

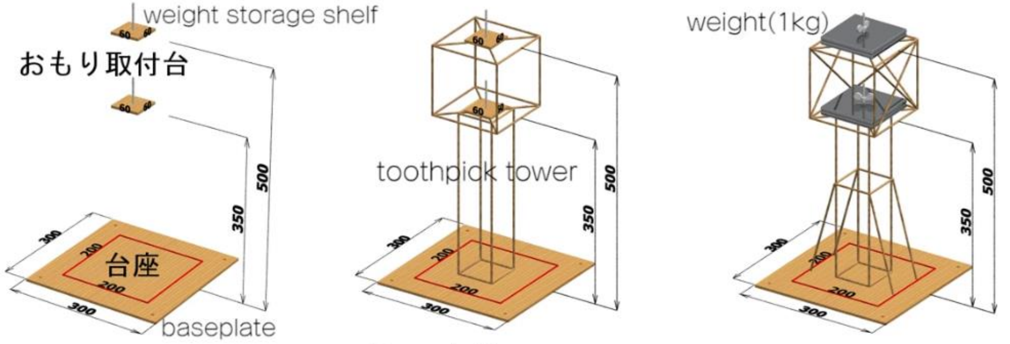
- Some STEM project examples that were implemented in classes and found to be effective.
- Some of these projects are widely known, some of them are not.
- They do not use strict steps, there are only regulations on size, time and materials.
- The final product/material is unique to the students and the design dependent on students’ creativity, imagination and experience.
- Note that the total effectiveness of a science project is dependent on the implementer.



Good practices: STEM lab. as the R&D lab.

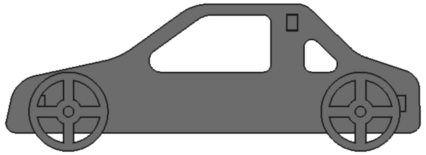
- Toothpick Towers (https://www.youtube.com/watch?v=RP8KcyCFrFQ, a university competition from Japan)





Regulations

Create a tower with two weight storage shelves at 350mm and 500mm height within the 200mm square of the baseplate. This toothpick tower should be made using toothpicks and wood glue, its weight should not exceed 85g.



Good practices

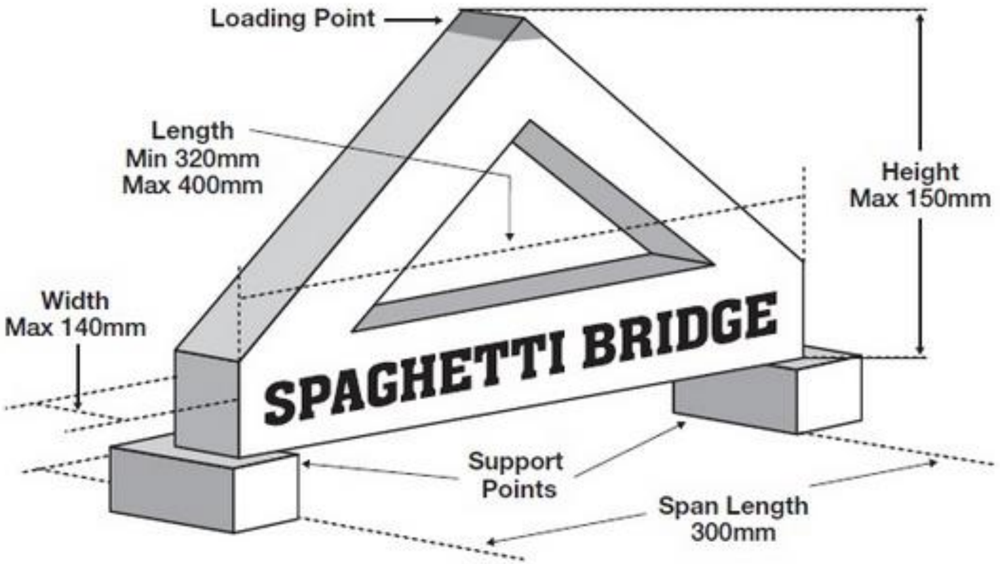
- Spaghetti Bridge (https://www.youtube.com/watch?v=SIqtGDYTJSA&t=259s, https://www.apegm.mb.ca/SpaghettiBridgeRules.html)

Spaghetti Bridge Competition Rules

Grades K-12 | Individuals or teams (max 3 students from the same grade)

Official Rules

1. The trusses must span a 300 mm opening. Truss dimension rules are:
   - Length: 320-400 mm
   - Height: 150 mm maximum
   - Width: 140 mm maximum
2. The trusses must be made with **only** regular spaghetti and white or wood glue. So other pasta shapes are not allowed i.e. linguini.
3. To be eligible for prizes, the trusses cannot weigh more than 350 grams when completed. The trusses will be weighed before testing.
4. Entries must be made by the participant(s). Help from parents, guardians, or teachers will lead to disqualification from the competition.
5. The trusses will be loaded at the centre of their span (length) from the top until they break.
6. No horizontal support will be provided at the support points. The truss cannot bear on the sides of the support points (see picture below).
7. The truss holding the heaviest load wins! If there is a tie, the lighter truss wins!



Good practices

- Egg Drop

2020 EGG DROP GUIDELINES

GENERAL:

The contestants shall design and build a shipping container that will prevent an uncooked chicken egg (Grade A Large) from breaking when dropped from the first floor inside the Oliver H. Raymond building to the basement. At the discretion of the judges, surviving eggs will then be taken to the second floor of OHR and dropped a second time. The container must be less than 216 in^3 in volume with no single dimension longer than 10 inches. The maximum weight, including the egg, cannot exceed 2.5 pounds. Contestants must be able to remove the egg without damage.

MATERIALS:

Any material may be used in the design, as long as the structure meets the design and contest rules as outlined below.

DESIGN AND CONTEST RULES:

1. No kits or pre-made designs may be used. The structure must be the individual's invention.
2. The structure must be completely released (no strings or other attachments) NO PARACHUTES!
3. The structure must land in a designated target area.
4. No gases (i.e. helium) other than air can be present in the structure when it is weighed.
5. Volume will be calculated based on the outside shape of the container (inside air volume/space will **not** be subtracted out).

https://www.engr.uky.edu/sites/default/files/2020-Egg-Drop-Guidelines.pdf

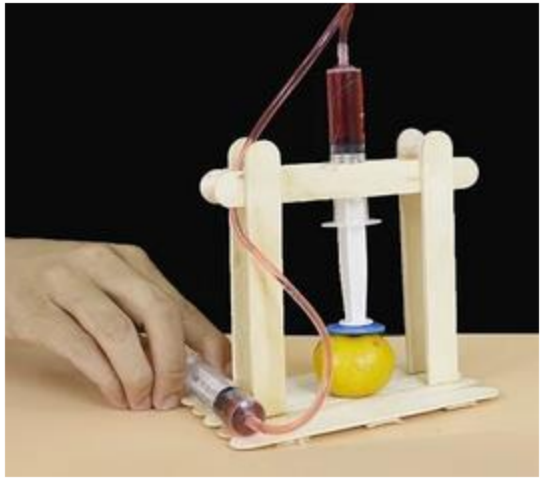
Good practices: STEM lab. as the R&D lab.

- Hydraulics Projects

NFPA Fluid Power Challenge Student Competition Secures the Workforce of Tomorrow

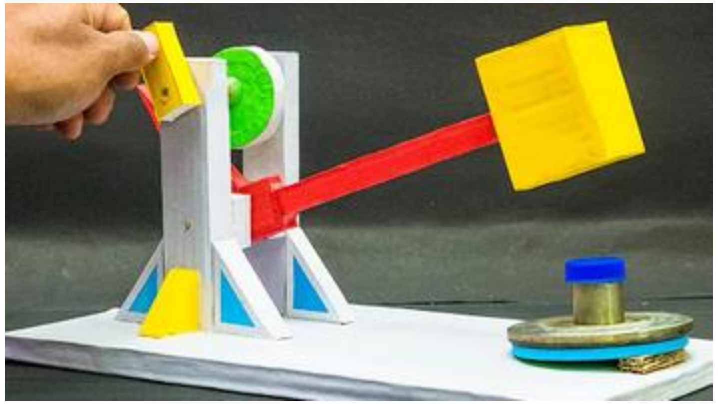
Posted on 06/30/2014 by Fluid Power Journal in Features · 0 Comments

National fluid power association (NFPA)



Good practices: STEM lab. as the R&D lab.

- Camshaft Toys Project (https://www.instructables.com/Mechanical-Cam-Toys/)



Challenge: Design and build a Cam Toy with motions and scenery that represent concepts related to the specified topic. Students may work in groups of 2 or 3. A Cam Toy base, rotating shaft, and a few cam designs are provided at this Tinkercad link. The base accommodates 2 motions. Students can modify the models to make smaller or larger machines.

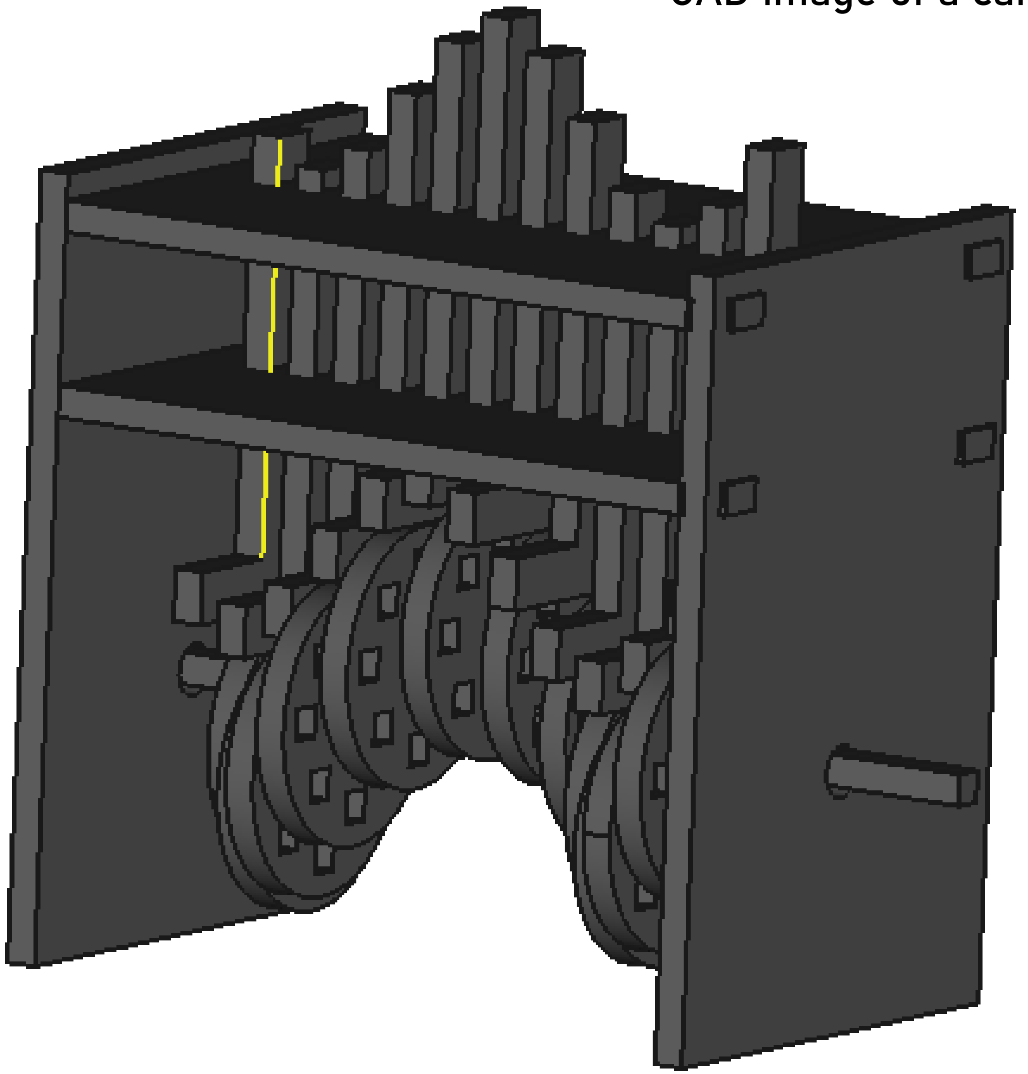
Criteria:

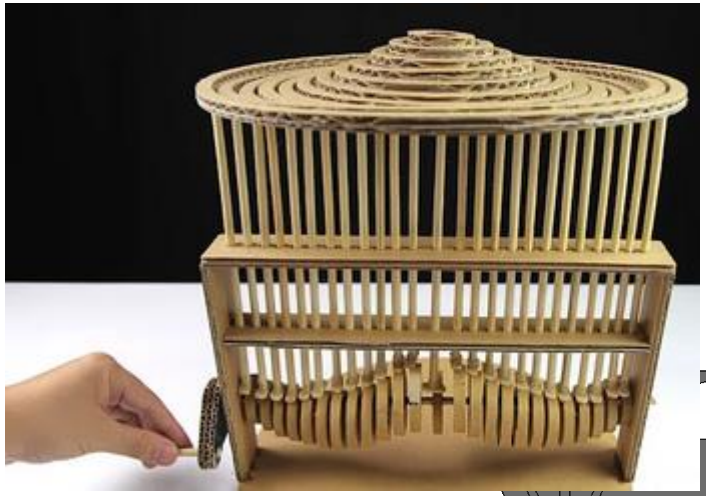
- Includes 2 characters/objects that move when the toy is operated. Possible motion types are:
- Includes 1 static object that is a background, piece of scenery, or other objects.
- The motions and scenery must represent concepts related to the specified topic.

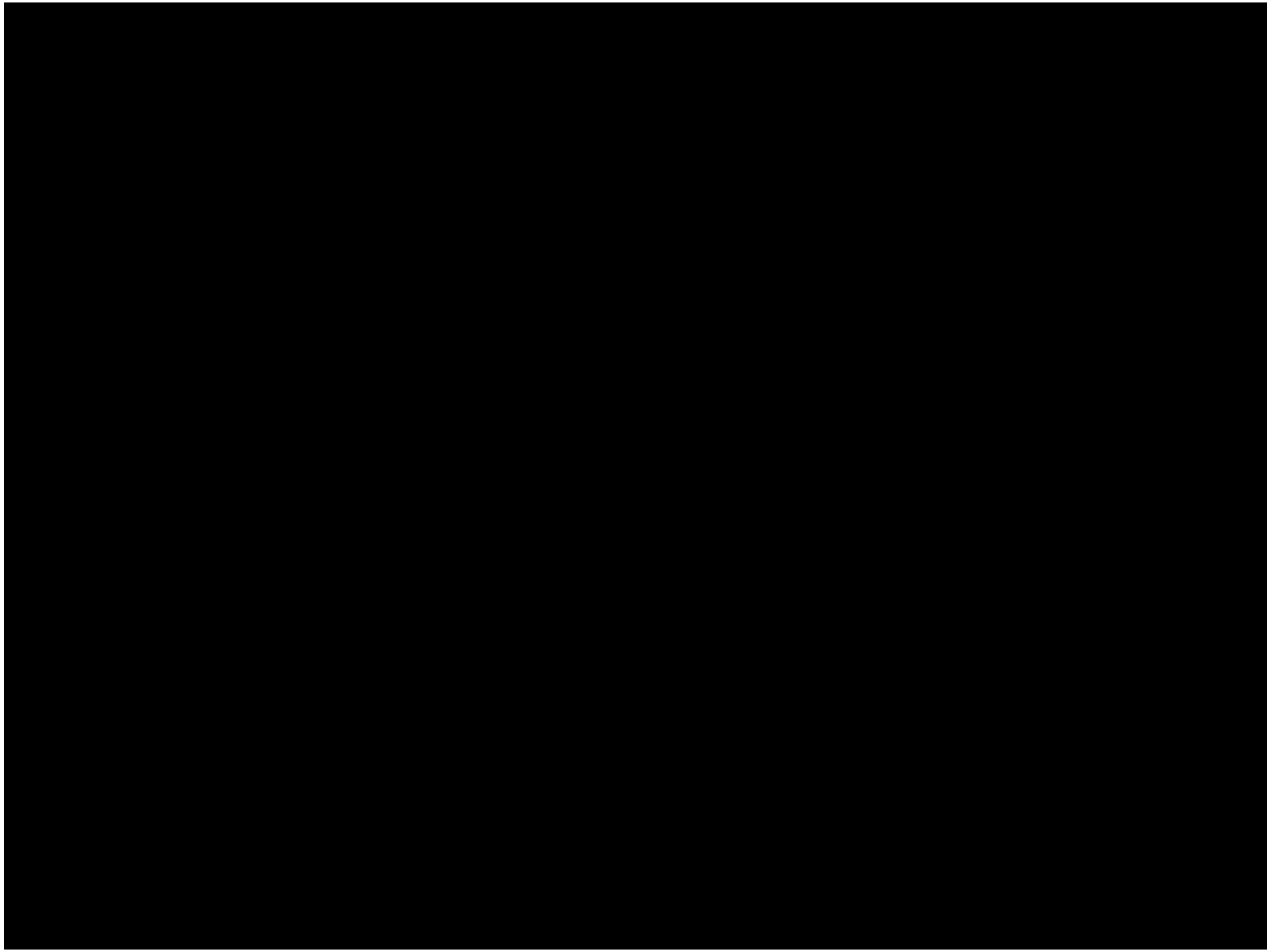
Constraints:

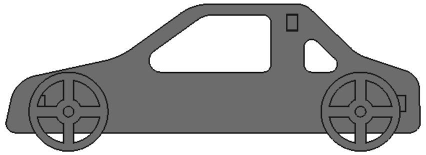
- The 2 motions must be different. The same type of motion can be used twice if the 2 motions differ either in frequency or magnitude. (For example, if there are 2 up-down motions 1 can have 2 rises/falls per cycle while the other has 1. For spinning, 1 can spin at a faster speed than the other.
- The appearance and motions of the characters and objects must communicate the intended concept.

CAD image of a camshaft toy



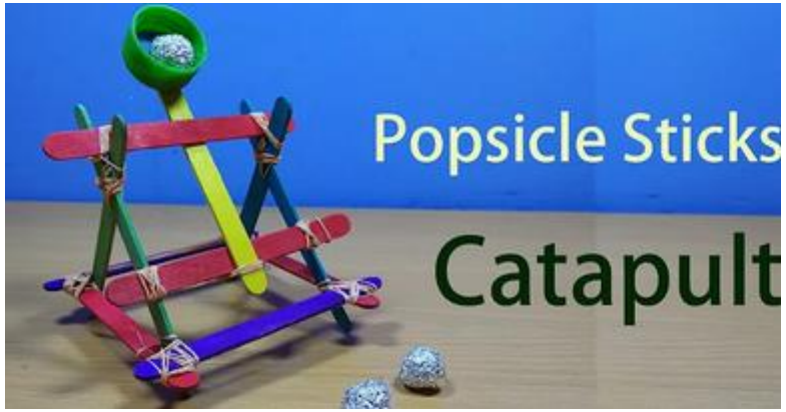






Good practices: STEM lab. as the R&D lab.

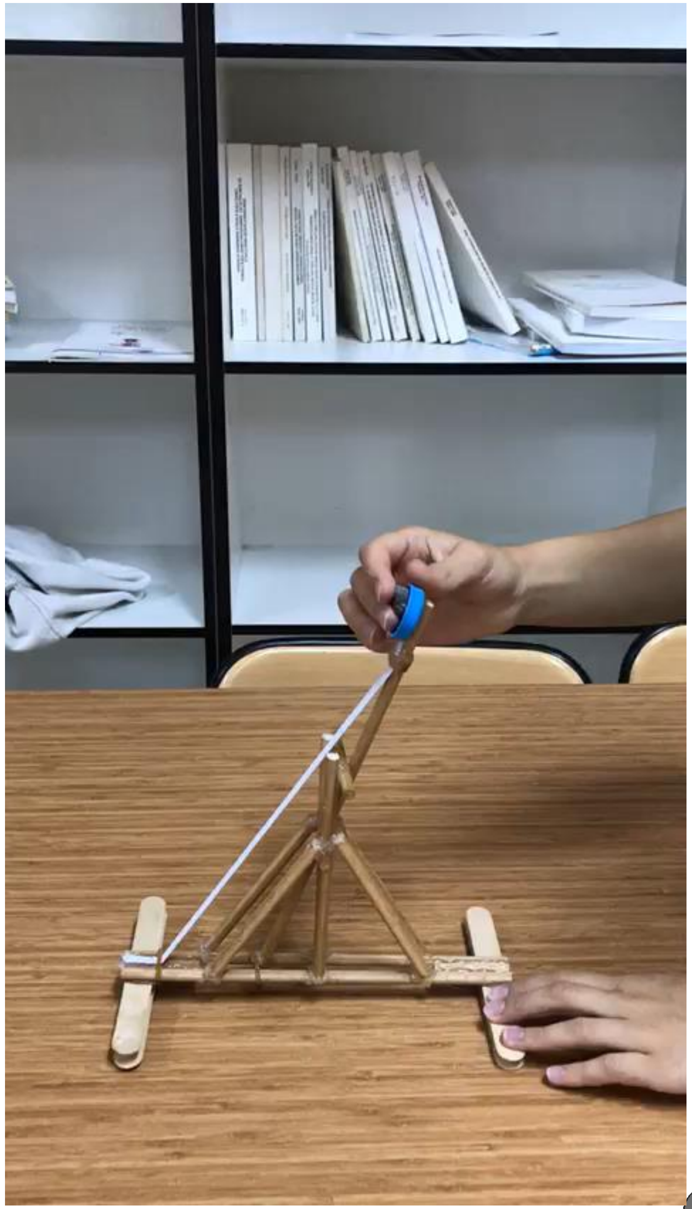
- Catapult Project



You can only use these materials for your catapult:

- Popsicle sticks
- Rubber bands
- Hot glue gun
- Anything can be used as your marshmallow holder on your catapult
    - For example, a spoon, or bottle cap
- Any markers and/or other coloring supplies may be used to decorate your catapult

- Groups of 1-2 people
- Only up to 4 groups can participate in launching marshmallows with their catapults at a time (due to flying marshmallow madness)
- You will have 1 minute and 30 seconds to get as many marshmallows in the baskets as possible.

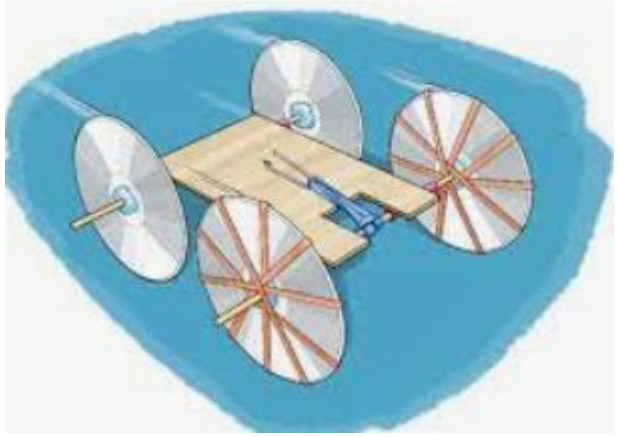


Good practices: STEM lab. as the R&D lab.

- Rubberband Car / Mouse Trap Car

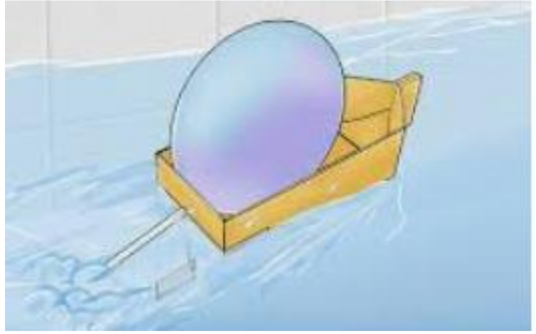
Guidelines:

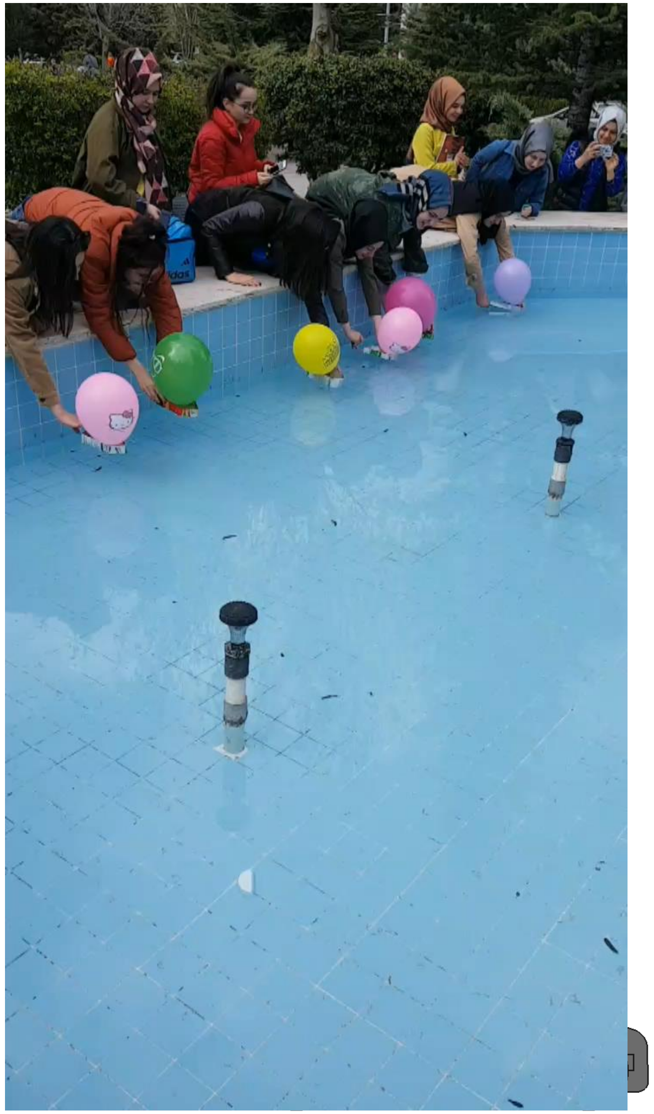
1. You may not propel the car in a slingshot fashion.
2. Your car must have at least 3 wheels.
3. Only household items, not intended for the purpose which you use them may be used!
4. Looks count, so make your car as attractive as possible.
5. No mousetraps allowed!
6. You cannot make wheels, use only objects that are already round.
7. No Legos, K'nex, erector sets, construx, etc. or pinewood derby materials allowed.
8. No coffee cans or similar structures are allowed.
9. Any car that does not meet these guidelines will be given credit as being done, but will not be allowed to be tested.



Good practices: STEM lab. as the R&D lab.

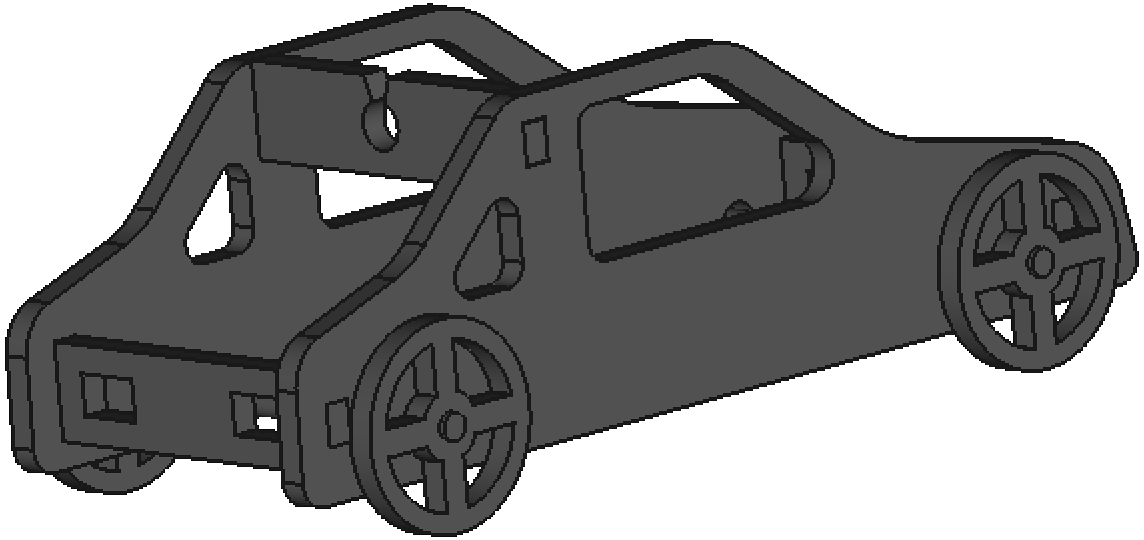
- Balloon Boats (if you have a pool)





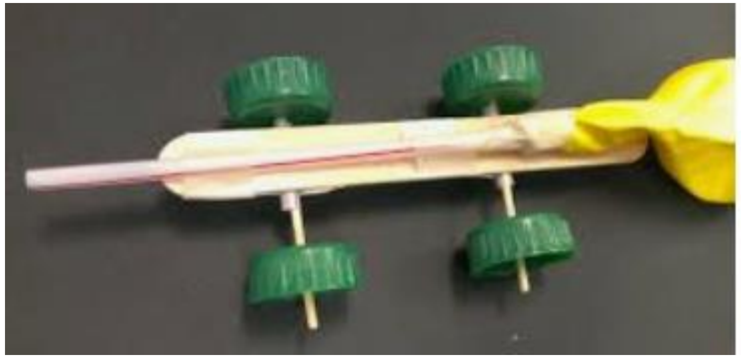
Good practices: STEM lab. as the R&D lab.

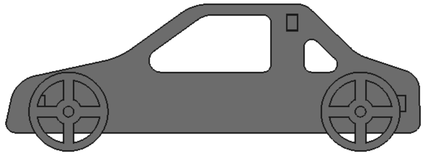
- Balloon Car



CAD image of a balloon car

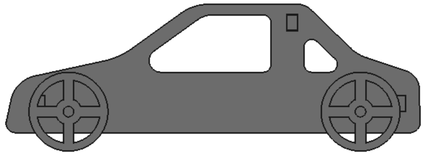
Can be produced in laser cutting or 3D printing





Question

- Which of these projects have you tried before in your science courses?

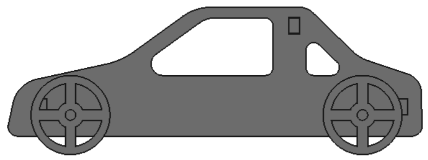


Good practices: How to manage the R&D lab.?

- Students always try to be the best.
- We can get advantage of this motivation using Research & Development models.
- Make sure that the design is not a final product and it can always be developed.

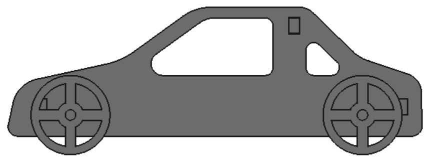
- For example, if a balloon car is very light in mass, it can spin; if it is very heavy it will not move.

- Rubberband car is very different compared to the balloon car. It needs much more friction in order to transfer the energy stored in the rubber to the ground.



Good practices: How to manage the R&D lab.?

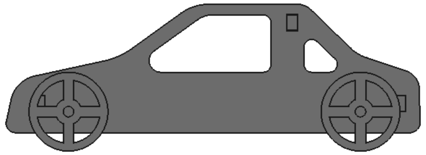
- When you are carrying out a project;
  - Try to develop scientific literacy by asking them a lot of question. For example:
    - What will happen? → Predicting
    - How long do you think it will move? → Estimating
    - How long did it move? → Measuring
    - What is different in your design than the others? → Comparing
    - What happened? → Observation
    - Why happened? → Inferring
    - What would you change for more distance? → Defining variables
    - What will happen if you do that? → Create hypothesis
    - Record the data and create a graph on this relationship → Collect & analyse data
    - Evaluate your design or other designs → Critical thinking, analytical thinking
    - Investigate who first used this mechanism in history → HPNS issues
    - What is the total cost of this product? → Entrepreneurship



Thank you for your attention.

Hakki Ilker KOSTUR, PhD.
Baskent University
Faculty of Education
Ankara, Turkiye

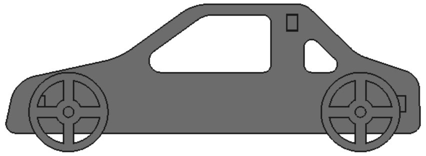
kostur@gmail.com



Simple Activity Plan: The water-gauge problem (Problem-based and history of science oriented STEM activity)

- Your house has a water tank at the basement. You have to fill it manually when the water level is low. It is not easy to see inside the tank and as the surfaces of the tank is thick, water level can not be seen from outside.

- Design a mechanism that works continously to show you the water level. You can not use electrical equipment.



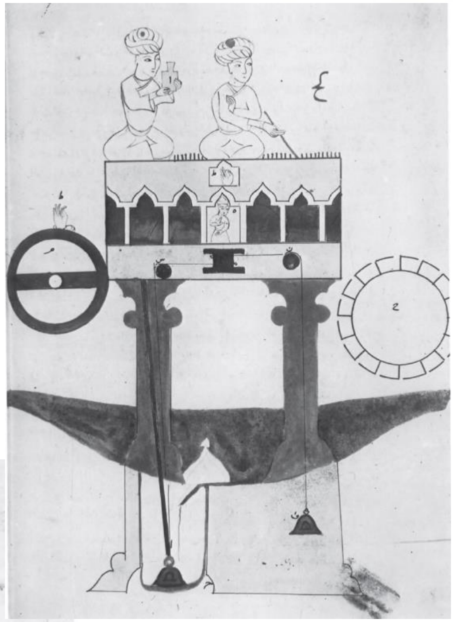
What is a water-gauge?

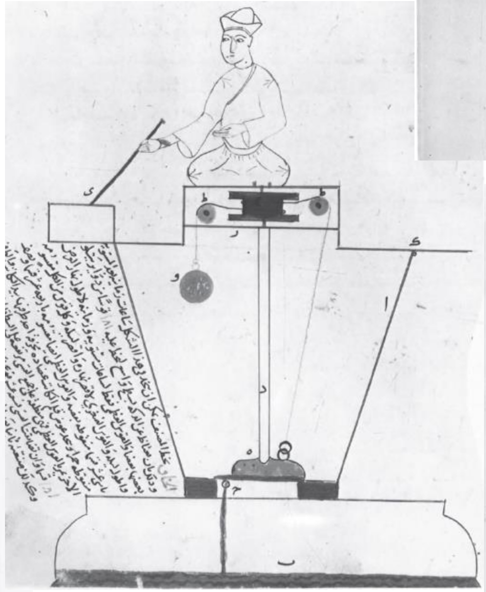
- A physical mechanism that uses buoyancy to indicate the water level (or manipulate with the water level) in a container.

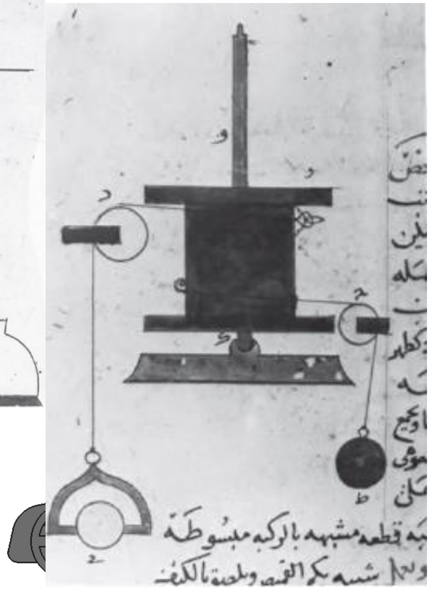
- Professional boilers, vehicles, industrial liquid tanks, toilet syphons are examples that we can observe a water gauge.

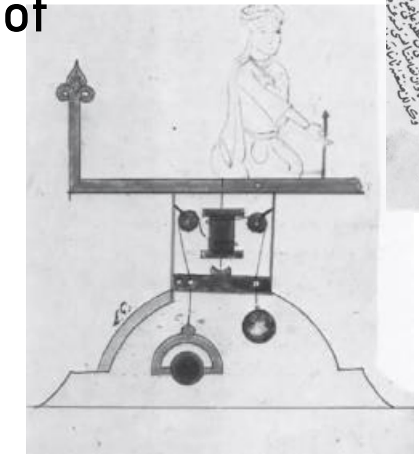
The water-gauge (*tarjahar*)

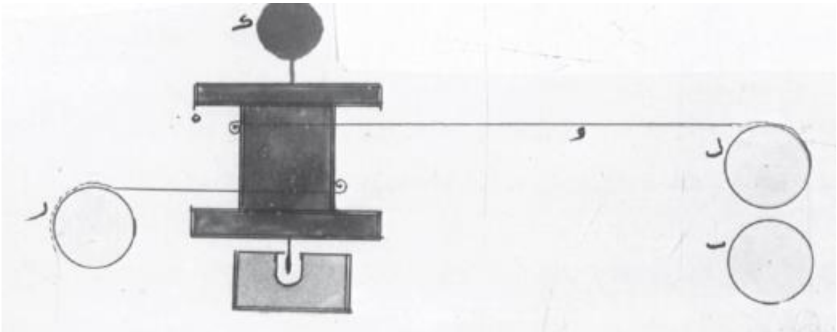
- Most of al-Jazari's designs were relied on water flow.
- al-Jazari described a mechanism named *tarjahar* which is used to rotate a rod by using buoyancy.
- It can be seen in several mechanisms proposed by him.
- It has variations adapted to the purpose of the mechanism.
- They were used to move figures of musical instruments or clocks or, show the liquid level of blood containers.



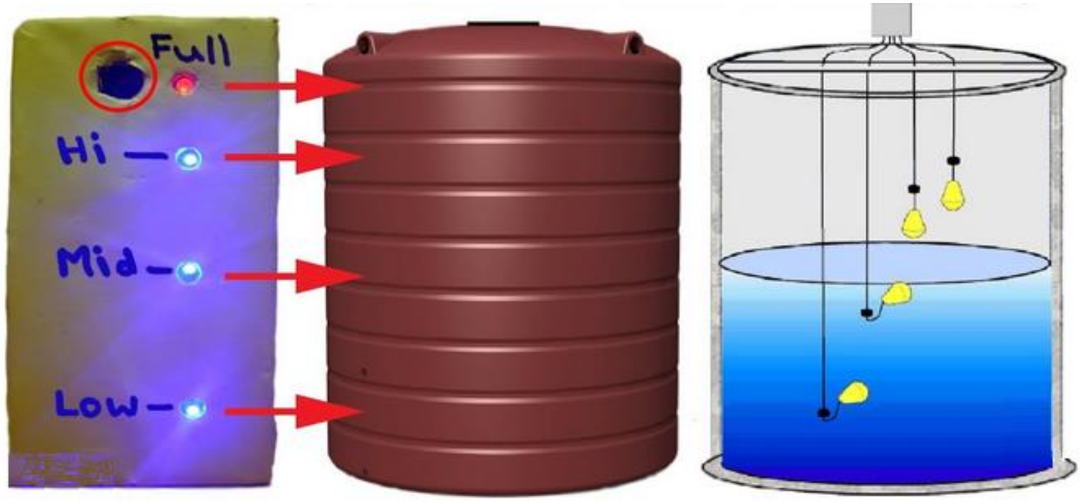


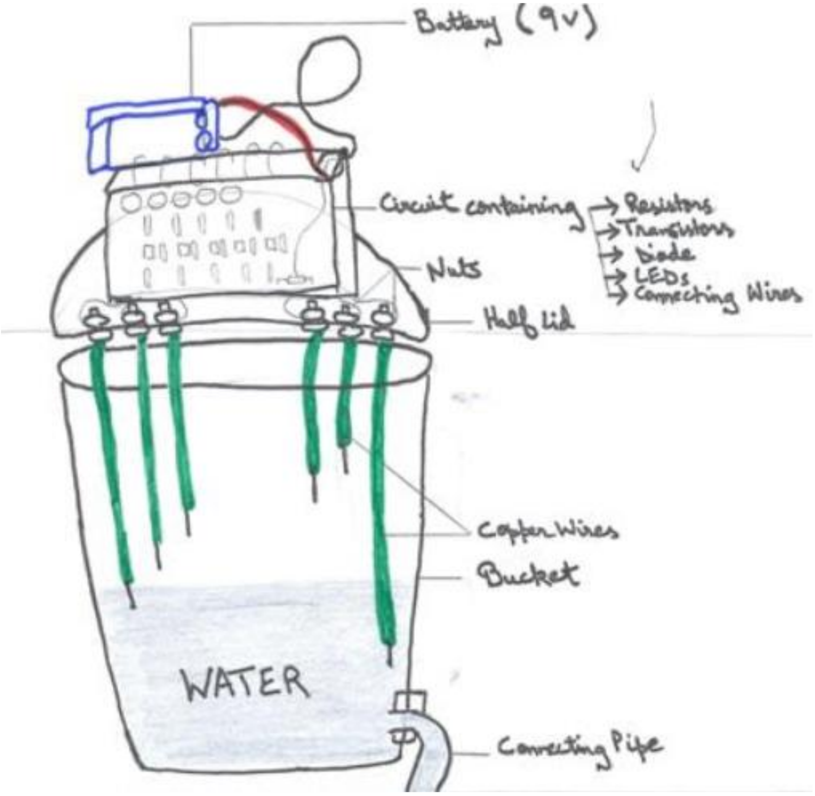


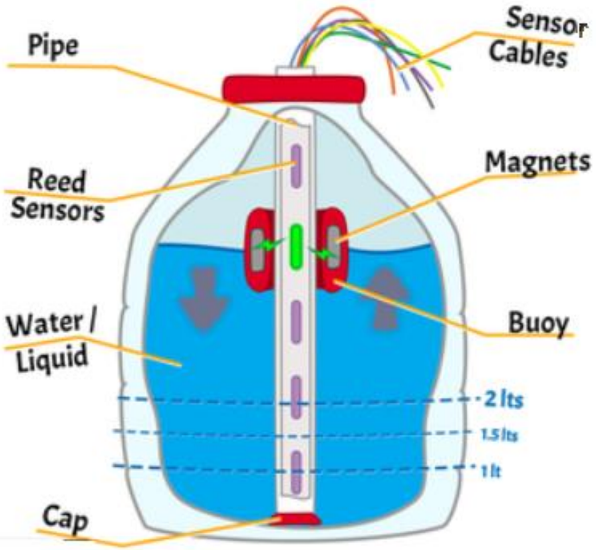


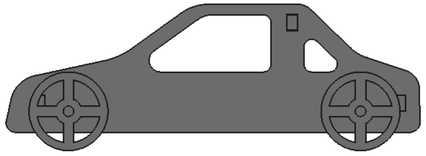


IDEAS

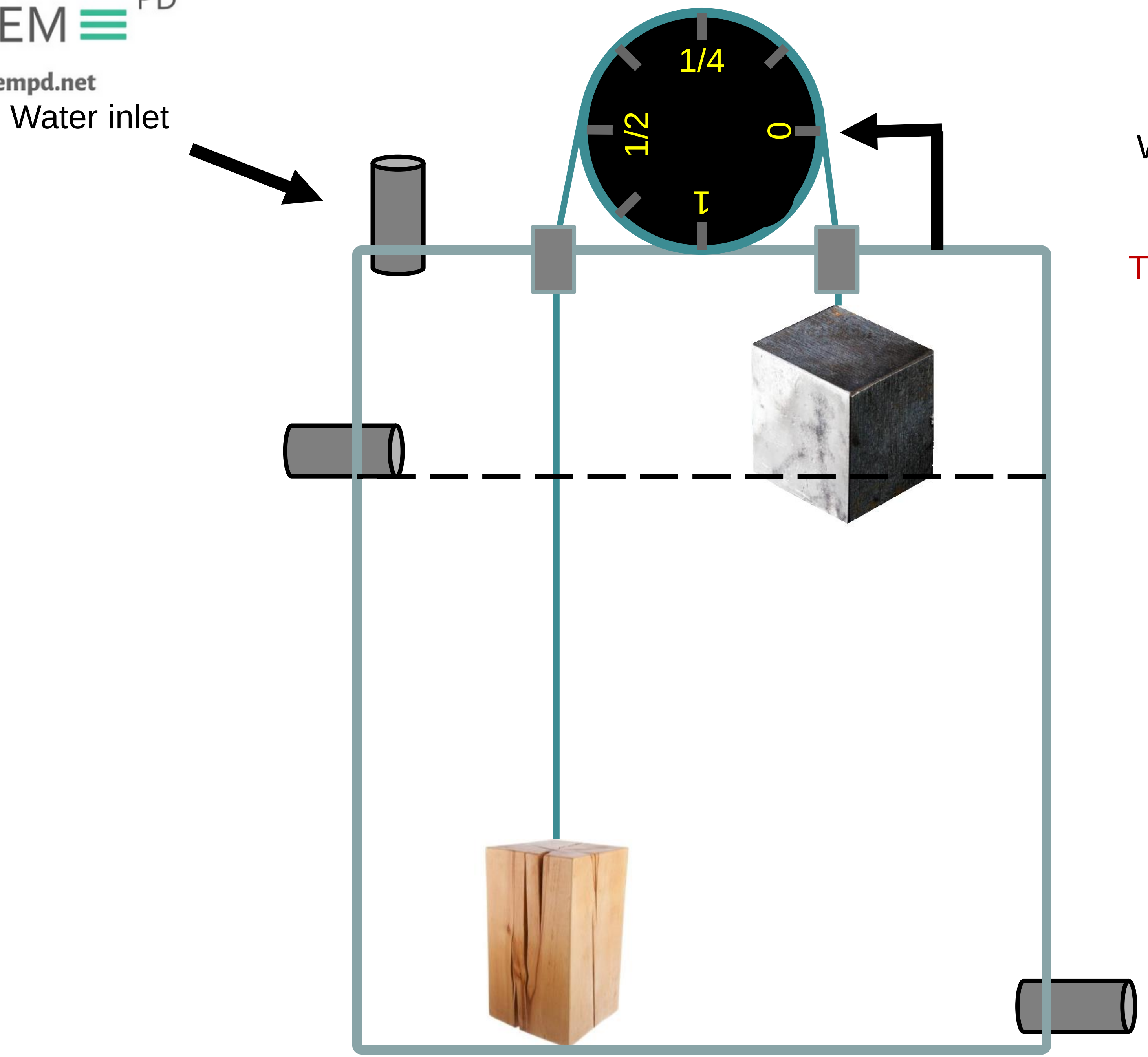

Full
Hi
Mid
Low


Battery (9v)
Circuit containing
Resistors
Transistors
Diode
LEDs
Connecting Wires
Nuts
Half lid
Copper Wires
Bucket
WATER
Connecting Pipe


Pipe
Sensor Cables
Reed Sensors
Magnets
Water / Liquid
Buoy
2 lts
1.5 lts
1 lt
Cap



STEM PD
stempd.net



OUR BEST RESULT from MIDDLE AGES

WATER CONTAINER WITH the WATER-GAUGE
(or liquid level indicator)

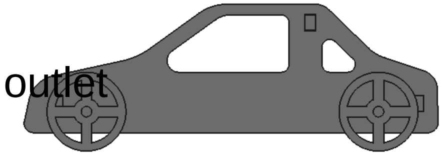
The metal part can also be mounted outside of the container as seen in al-Jazari.

Maximum level of water (Drain)

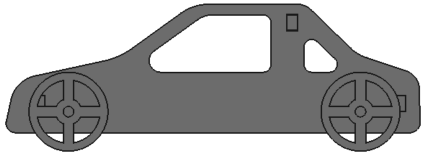
Block of iron
(*5 dirham* = approx. 15 grams)

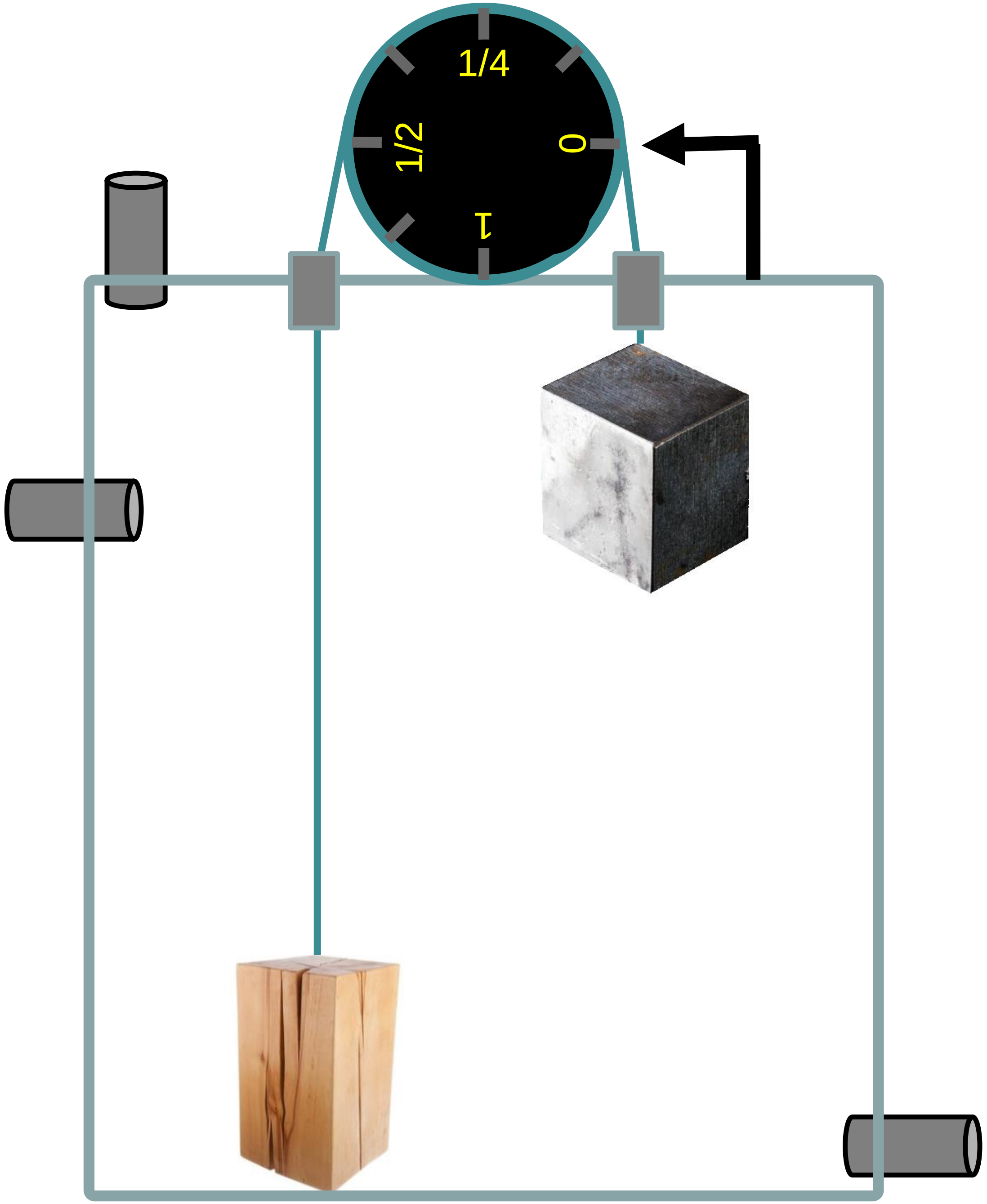
Block of wood
(*20 dirham* = approx. 60 grams)

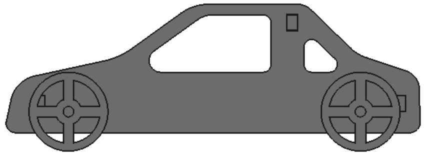
Water outlet



- https://ibb.co/Ltwk2mm

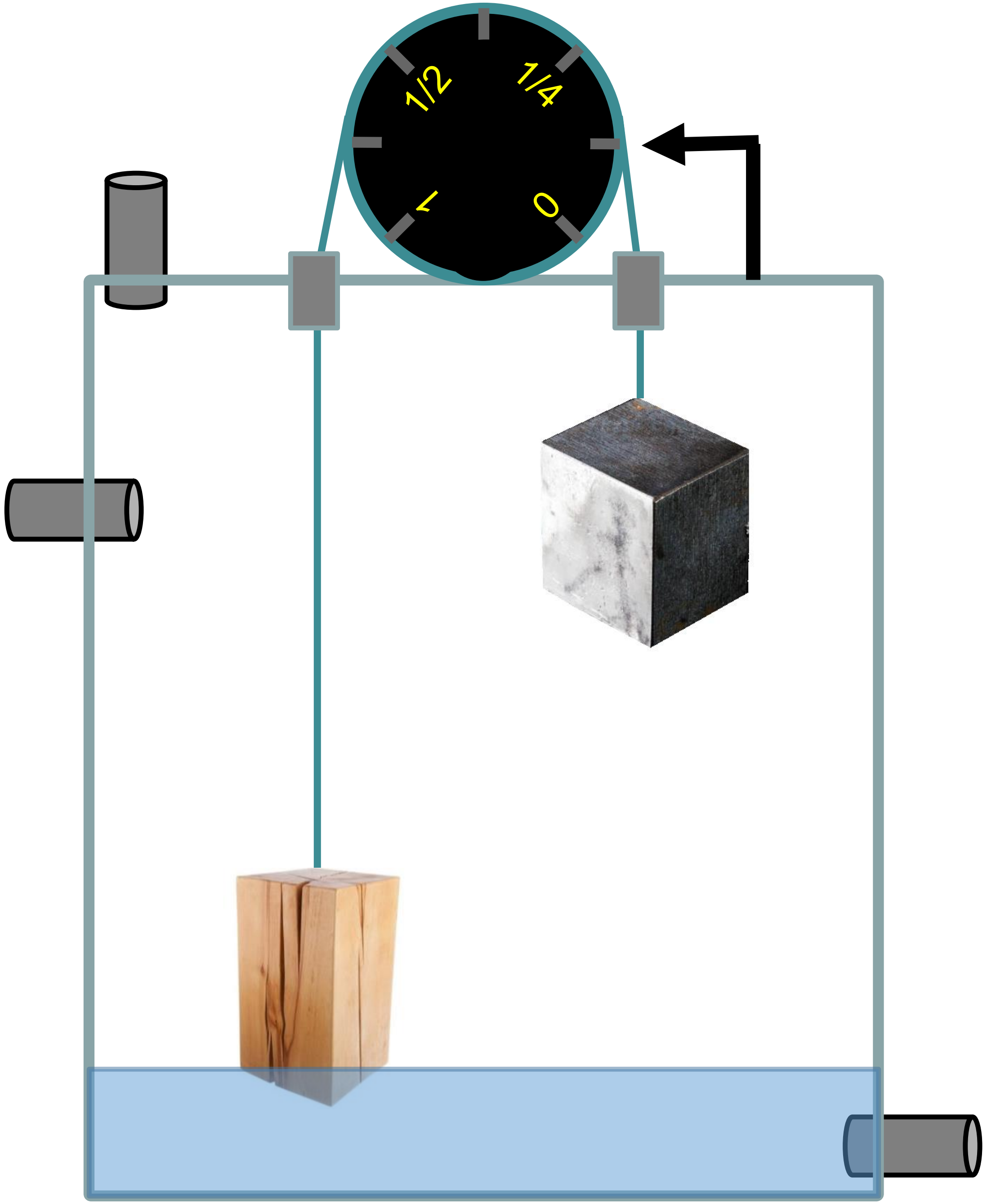


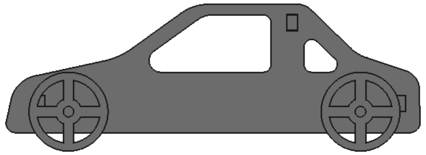

1/4
1/2
0
1



STEM PD
stempd.net

ICSE
International Centre for STEM Education





STEM PD
stempd.net

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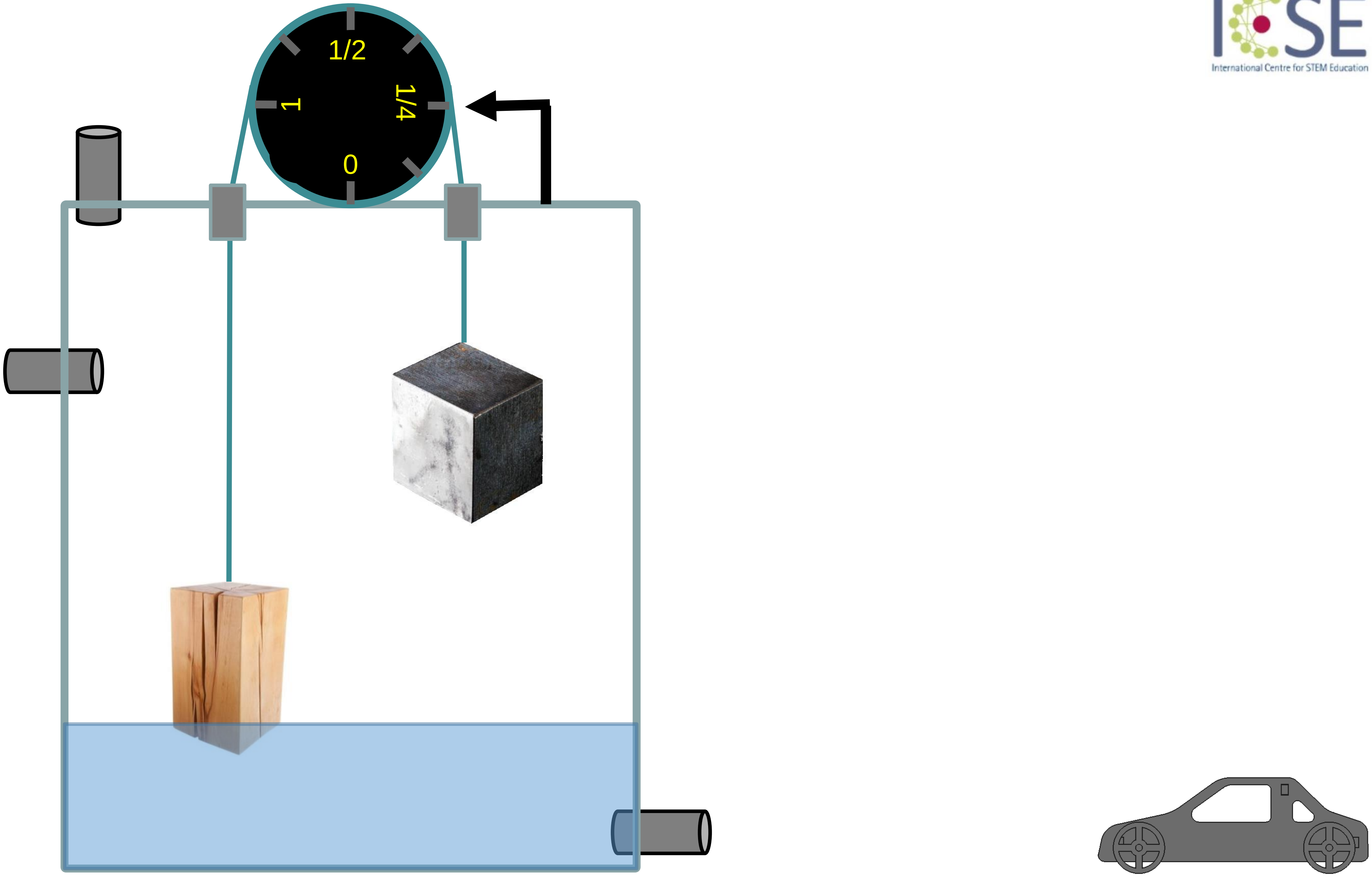

STEM PD
stempd.net

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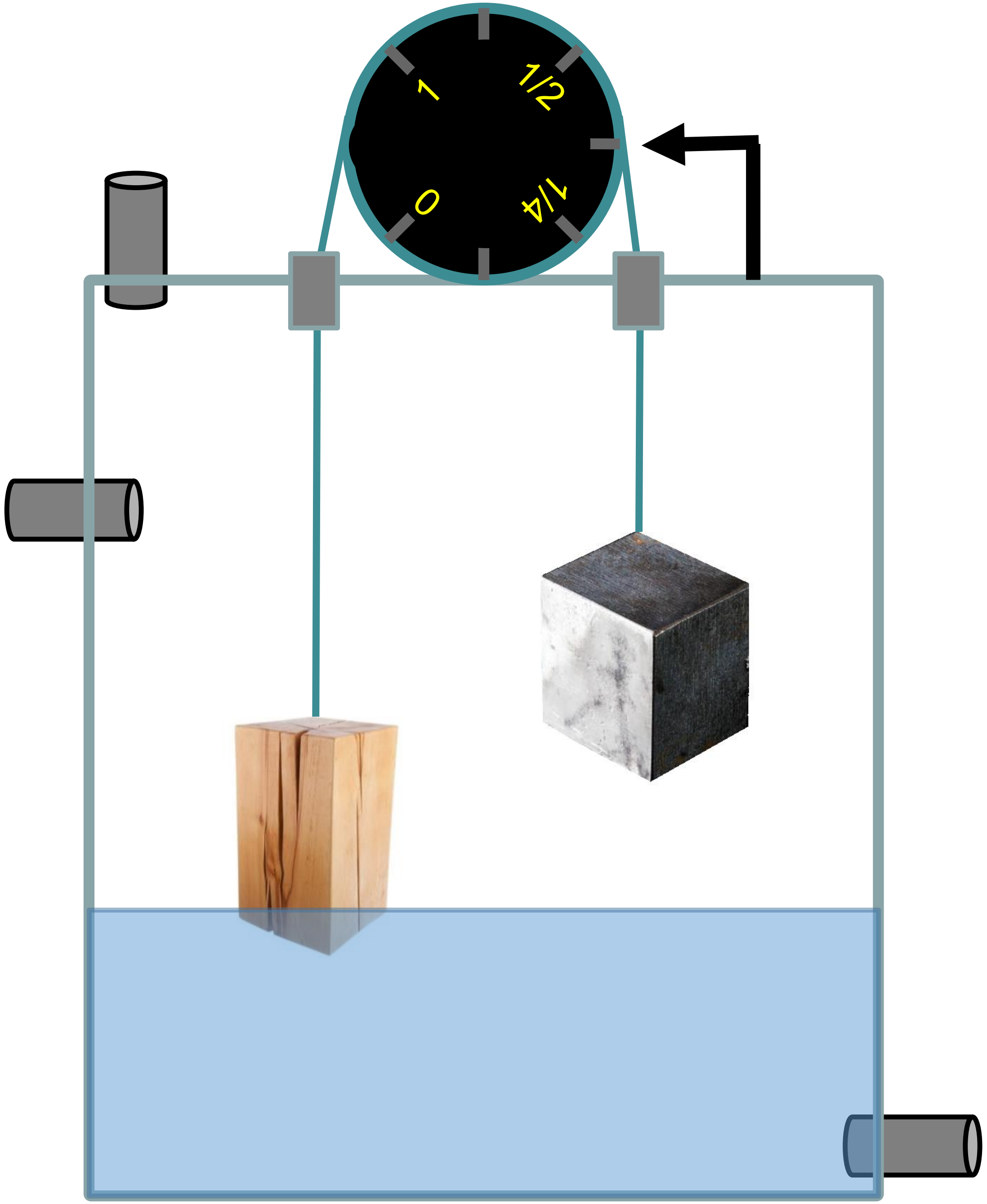
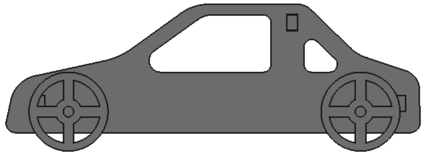
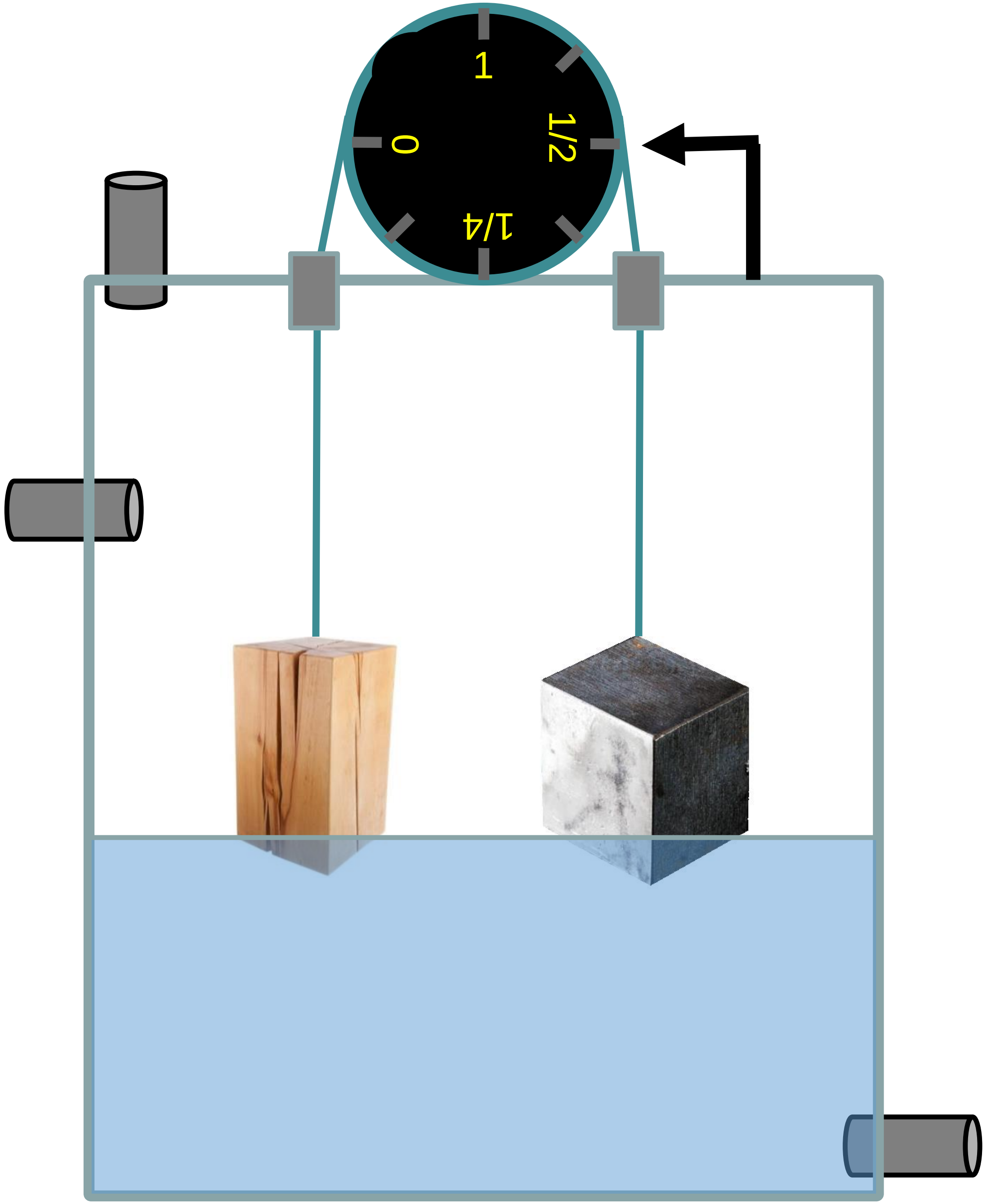
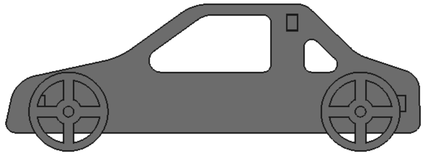
International Centre for STEM Education

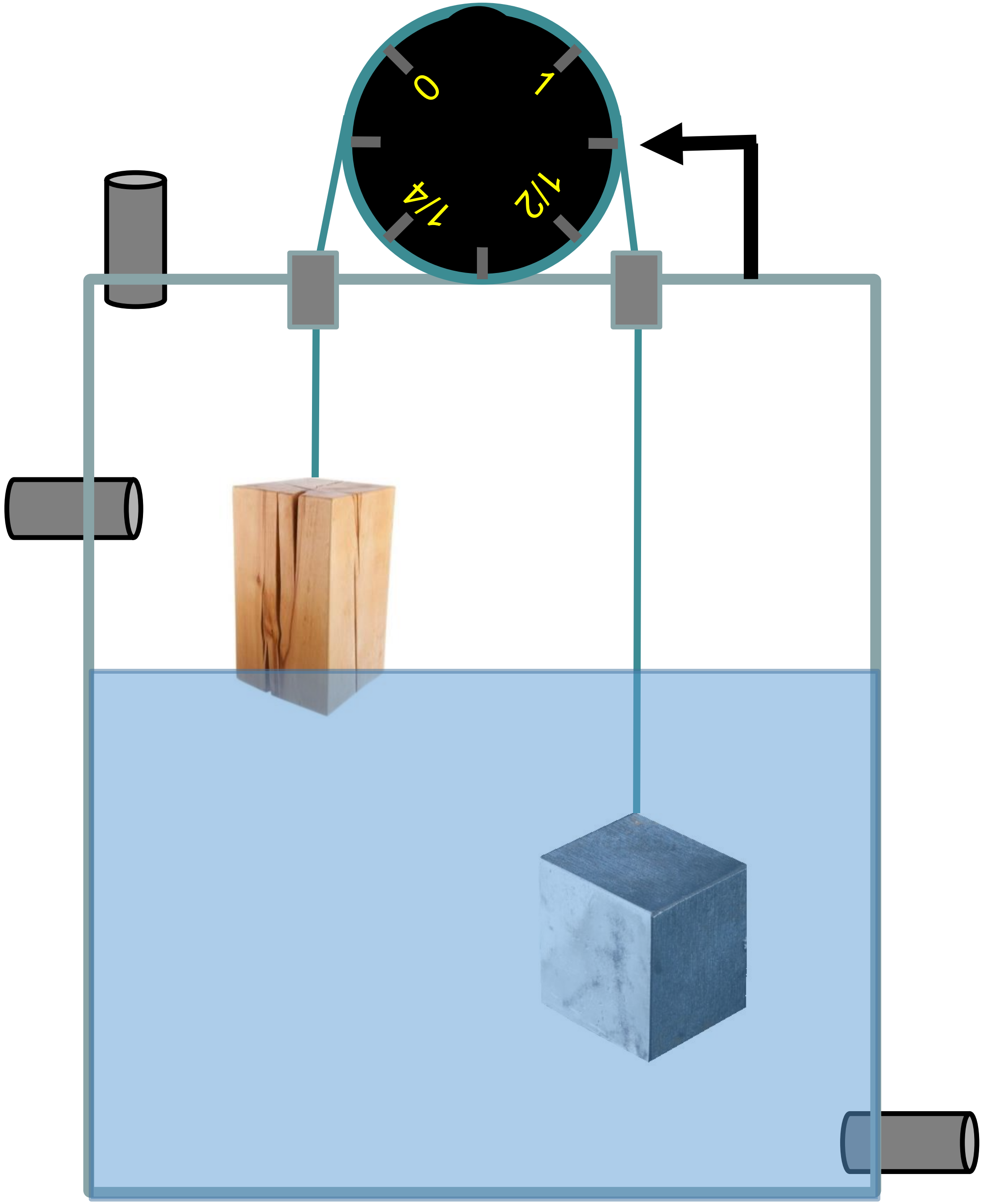




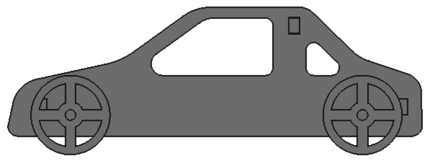
STEM PD
stempd.net

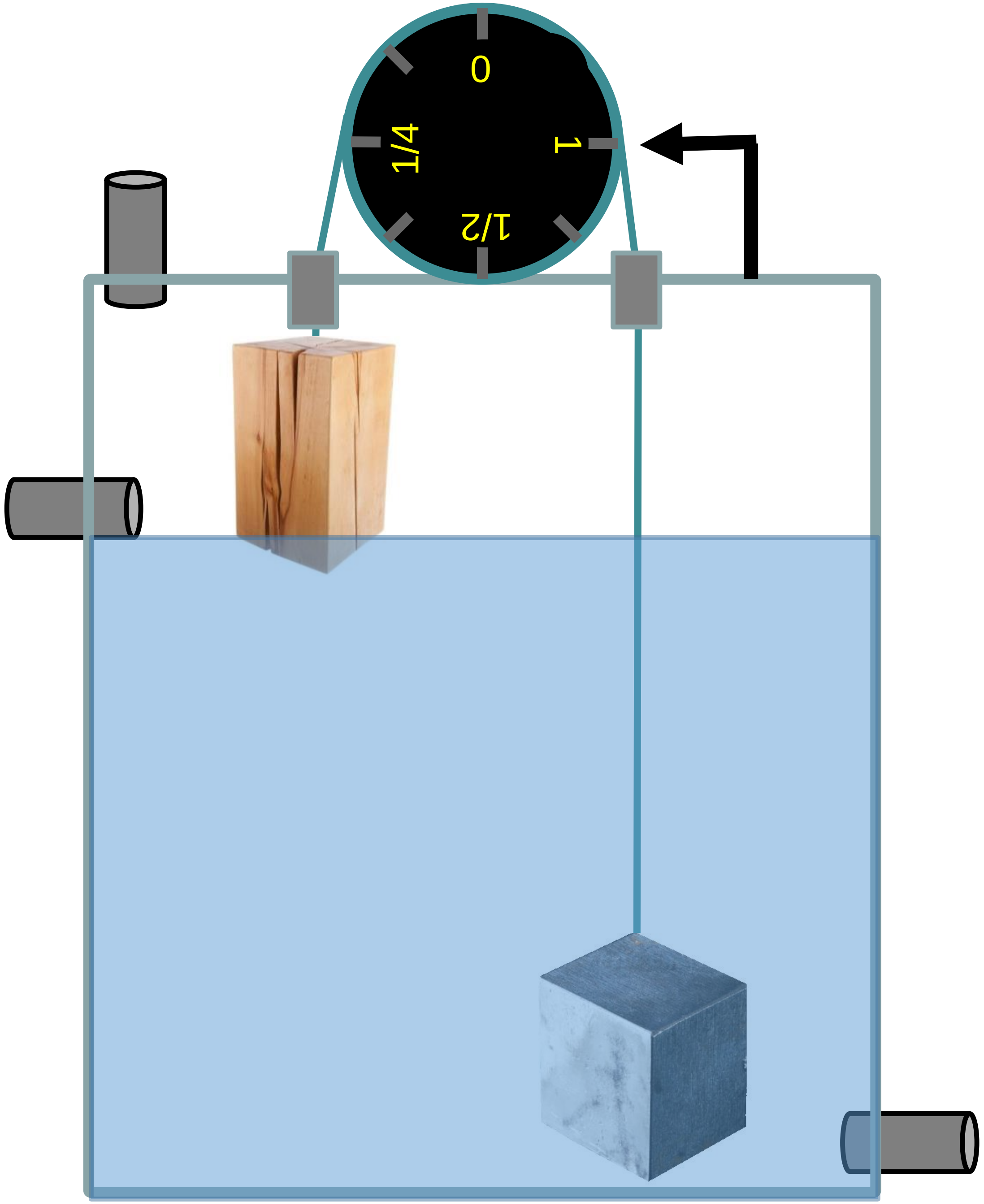


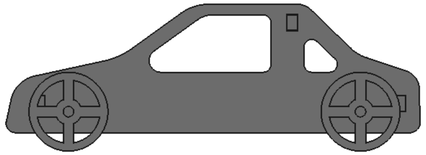




0
1
1/4
1/2

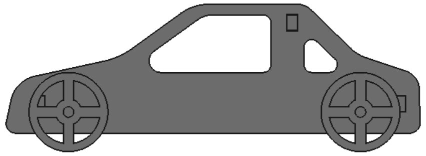



0
1/4
1/2
1



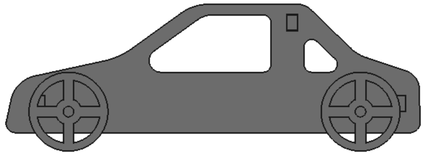
The water-gauge object as a learning material

- **Concepts related to the object:**
  - Buoyancy, density, sink-float, heavy-light, empty-full
- **Pedagogical outcomes:**
  - Experimenting, material design, collaborative group work, problem-solving, inquiry
  - Science process skills
  - History and the nature of science
  - HOS-STEM*
  - Creativity and imagination
- **Scope:**
  - Middle or high school science/physics courses, university science laboratory courses.



The water-gauge object as a learning material

- The legacy:
  - History is full of materials which can be used in classrooms today in order to teach the pedagogical outcomes listed previously.
  - The water-gauge is just an example which is easy to build with easy to find materials.
  - How and when it can be used, which concepts/topics to be taught with this object,
  - or determining the extent of history and the nature of science content in this object is heavily dependent on the implementer.



Thank you for your attention.

Hakki Ilker KOSTUR, PhD.
Baskent University
Faculty of Education
Ankara, Turkiye

kostur@gmail.com