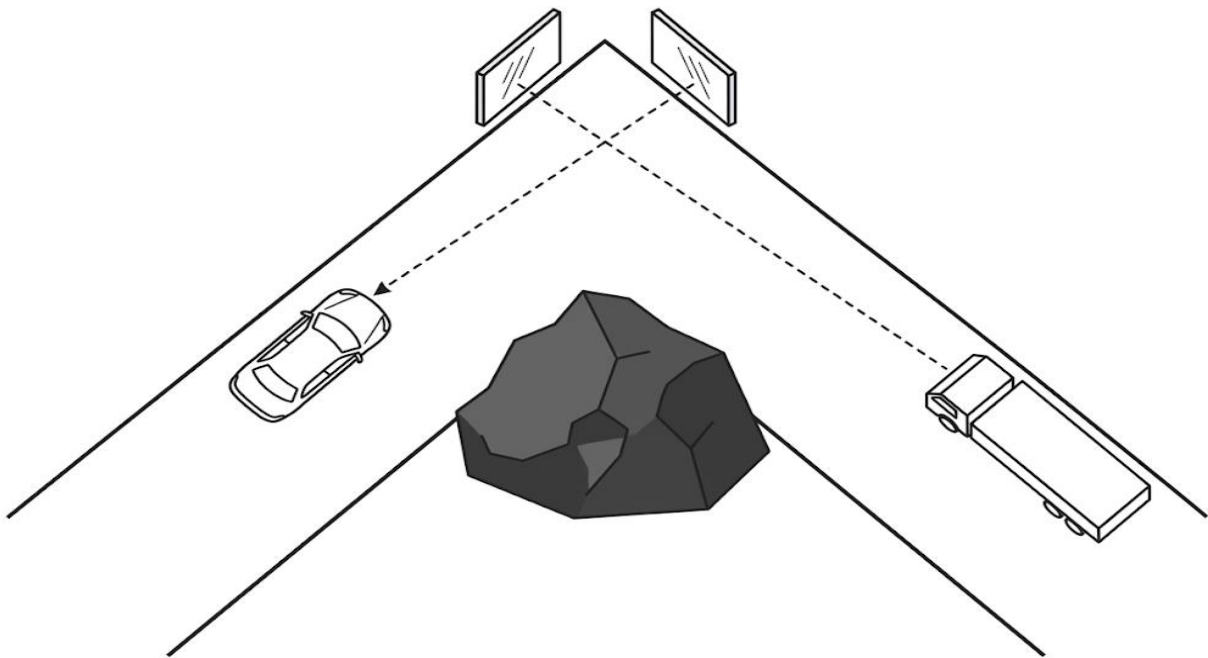


ITEM 1:

In the mountainous district of Kapchorwa, eastern Uganda, a narrow road features a sharp 90-degree "blind" bend carved into a steep rock face. Due to the obstruction, drivers approaching from either side cannot see oncoming traffic, leading to frequent head-on collisions. To resolve this, a local technician suggests installing a system of two large plane mirrors, M_1 and M_2 , at the vertex of the bend. The mirrors are intended to reflect light from oncoming vehicles around the rock face to the eyes of drivers on the opposite side.

However, during a recent storm, strong winds caused the mounting of mirror M_1 to loosen, resulting in its rotation. Drivers now complain that the viewing angle has shifted, making the safety system less effective.



Task

- Using the laws of reflection, explain the arrangement of the two mirrors that would allow a driver to see an oncoming vehicle clearly around a 90-degree bend.
- If the technician initially set the two mirrors at an inclination of 70° to each other, calculate the total deviation produced in a ray of light from an oncoming truck that reaches a driver after reflecting once from each mirror.
- Suppose the wind rotates mirror M_1 through an angle of 8° while M_2 remains stationary. Determine the angle through which the reflected ray reaching the driver shifts, and advise the community on how to improve the stability of the system to maintain its problem-solving utility.

ITEM 2:

Bududa District is known for its steep, winding roads that cut through the foothills of Mount Elgon. At one particular junction leading to the local health center, there is a blind corner caused by a massive rock outcrop. Motorists exiting the health center cannot see vehicles approaching at high speeds from the main road until they have already entered the lane, leading to frequent collisions. The District Engineer has proposed installing a large curved mirror on a pedestal at the vertex of the corner to help drivers see around the bend. However, some community members are concerned that the images they see in the mirror look too small and too far away, leading to misjudgments in speed.



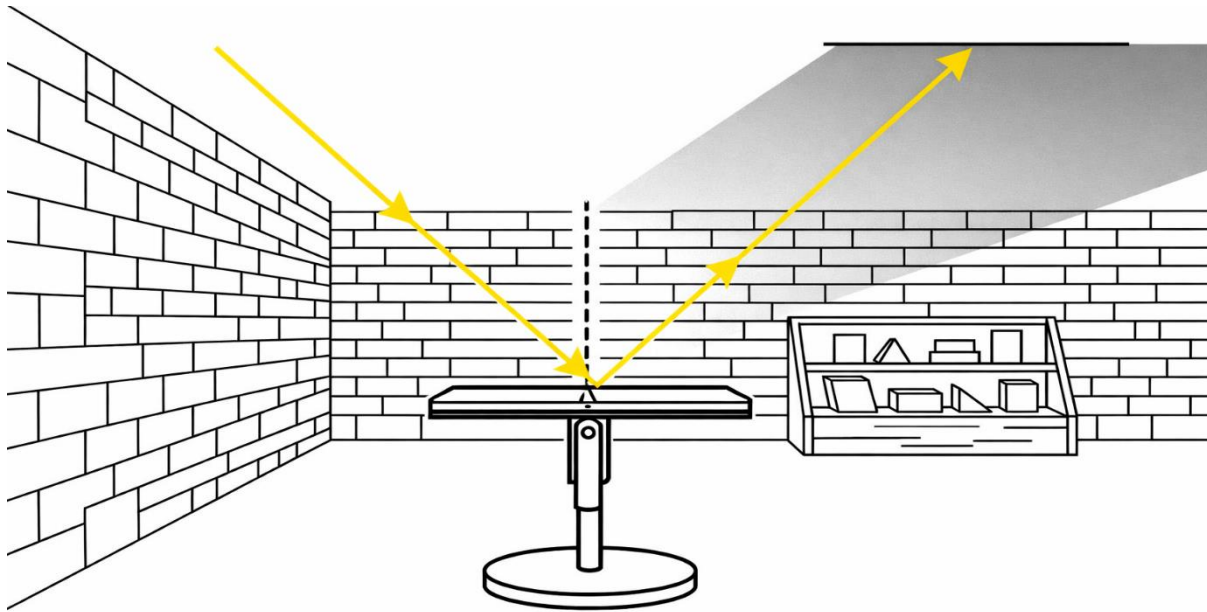
Tasks:

- Based on the properties of light reflection, identify the specific type of curved mirror the engineer should install. Justify your choice by comparing its field of view and the nature of images formed with other types of mirrors.
- Using a well-labelled ray diagram, illustrate how this mirror allows a driver at a specific distance from the vertex to see an oncoming vehicle. State three characteristics of the image formed that explain why the community members find it too small.
- The community's concern about misjudging speed is a significant safety risk. As a physics student, propose two practical solutions or safety guidelines the engineer should implement to help drivers use the mirror effectively without being misled by the image size.

ITEM:3

Mr. Okello, an innovative interior designer in Masaka City, is working on a renovation project for an old, deep-set shop that lacks sufficient natural lighting. To reduce electricity costs, he plans to use a large plane mirror mounted on a pivot near the entrance to redirect sunlight deep into the back of the store where a display of local crafts is located.

On a bright Monday morning, sunlight hits the mirror at an angle of 35° to the mirror surface. As the day progresses and the sun moves across the sky, the position of the reflected light beam begins to drift away from the craft display. Mr. Okello realizes that to keep the crafts illuminated without moving the entire mirror stand, he must precisely rotate the mirror on its central pivot. Furthermore, a new structural pillar has been built in the middle of the shop, necessitating the use of a second mirror to "guide" the light around the obstacle to reach the target area.



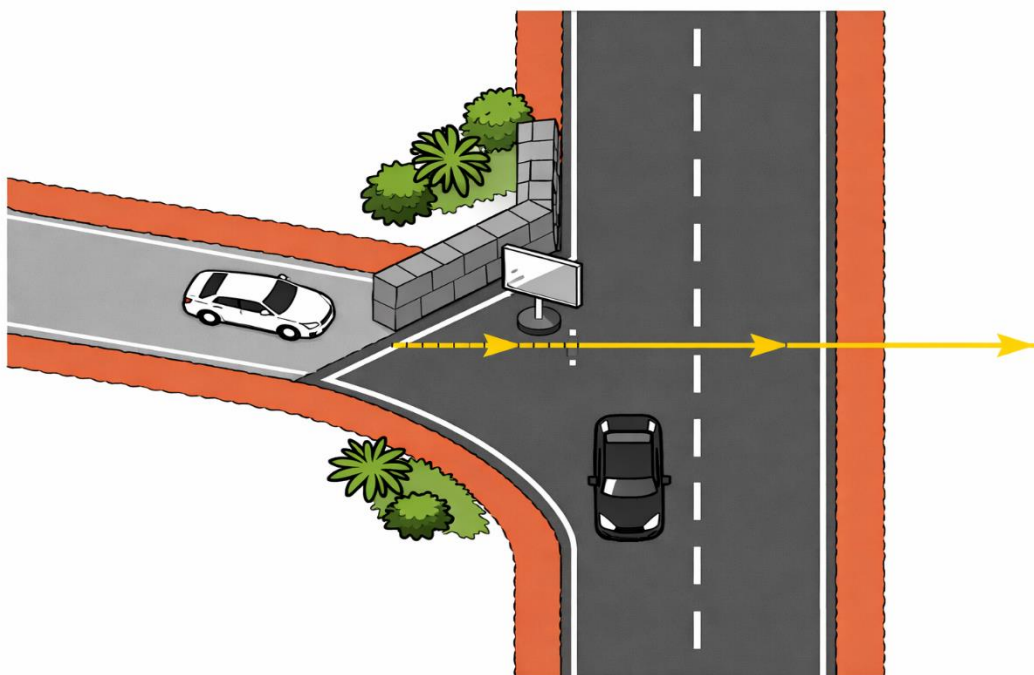
Tasks:

- Analyze the initial setup and, using the laws of reflection, determine the angle of deviation of the light ray from its original path. Explain why a plane mirror is more effective for Mr. Okello's goal compared to a rough, white-painted wooden board.
- Later in the afternoon, the reflected ray needs to be shifted by an angle of 24° to remain focused on the craft display, while the direction of the incident sunlight is assumed to stay momentarily constant. Calculate the angle through which Mr. Okello should rotate the mirror to achieve this.
- Design a setup using two plane mirrors that would allow Mr. Okello to bypass the structural pillar. Your design should specify the required orientation of the two mirrors relative to each other to ensure the final beam is parallel to the first reflected beam.

ITEM 4:

The residents of a hilly suburb in Mbale are concerned about a dangerous T-junction located on a steep slope. A tall, stone perimeter wall belonging to a new hotel completely blocks the view of oncoming traffic for motorists joining the main road from a side path. To prevent accidents, the local council chairperson has proposed mounting a large plane mirror on a pole at the corner of the junction.

During a community planning meeting, a veteran driver named Okello expresses concern. He argues that the mirror must be perfectly aligned and securely fixed. He claims that even a tiny accidental rotation of the mirror—perhaps caused by a minor bump from a boda-boda or strong wind—would result in a much larger shift in the reflected image, potentially causing the waiting driver to see a ghost path or lose sight of the oncoming vehicles entirely. The council has asked you, a Physics student, to validate these concerns and provide technical guidance for the installation.



Task

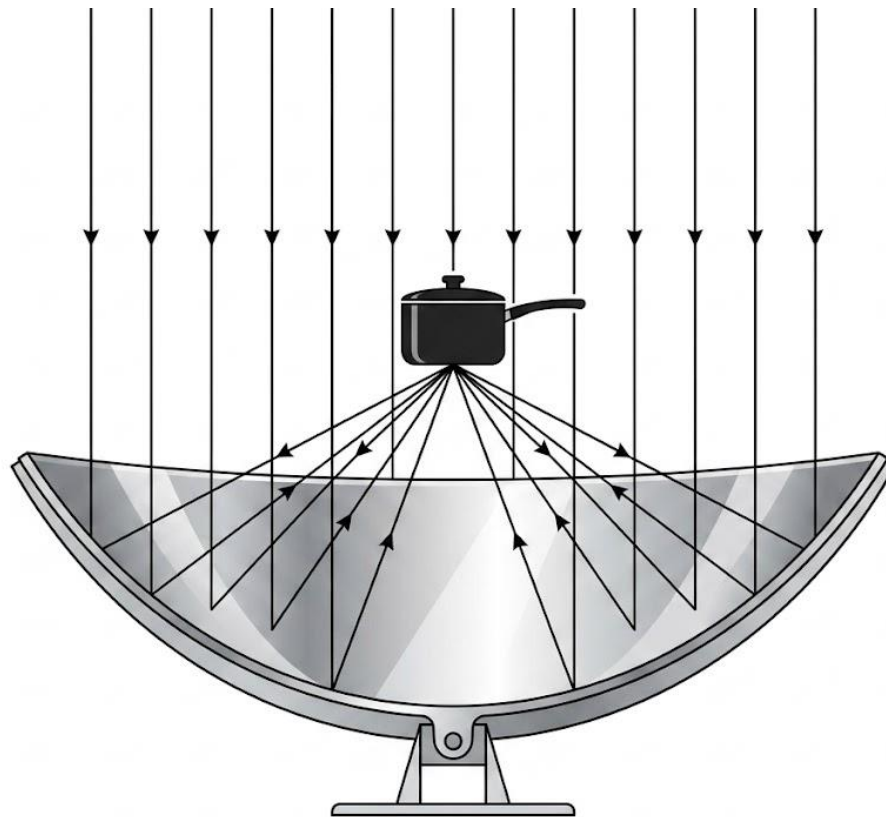
- Using a well-labelled ray diagram and the laws of reflection, explain how the plane mirror at the junction enables a driver to see a vehicle that is physically hidden behind the stone wall.
- Okello claims that a small rotation of the mirror causes a much larger shift in the reflected ray. Provide a mathematical derivation to show that if a plane mirror is rotated through an angle θ while the incident ray remains fixed, the reflected ray rotates through an angle 2θ .

- (c) Suppose the two roads at this specific junction meet at an angle of 140° . Calculate the glancing angle at which a light ray from an oncoming car must strike the mirror so that it is reflected directly to a driver waiting to join the main road.

1. Scenario:

In the rural village of Lwengo, Masaka, the rising cost of charcoal and firewood has made it difficult for families to prepare meals, leading to increased deforestation in the surrounding hills. Musa, a Senior Five Physics student, notices that the area receives intense, direct sunlight for over six hours a day. He suggests that the community could reduce fuel costs by building solar cookers using large, flexible sheets of polished aluminum.

Musa's first attempt using a flat, plane mirror from an old wardrobe failed to boil water, only making it lukewarm after several hours. He now has a polished aluminum sheet which he can bend into a curved shape with a radius of curvature of 2.4 meters. He intends to use this to focus sunlight onto a black-painted cooking pot. However, the village elders are skeptical about whether a "bent mirror" will work better than a flat one, and Musa must demonstrate the scientific validity and practical placement of the cooking pot to win their support.



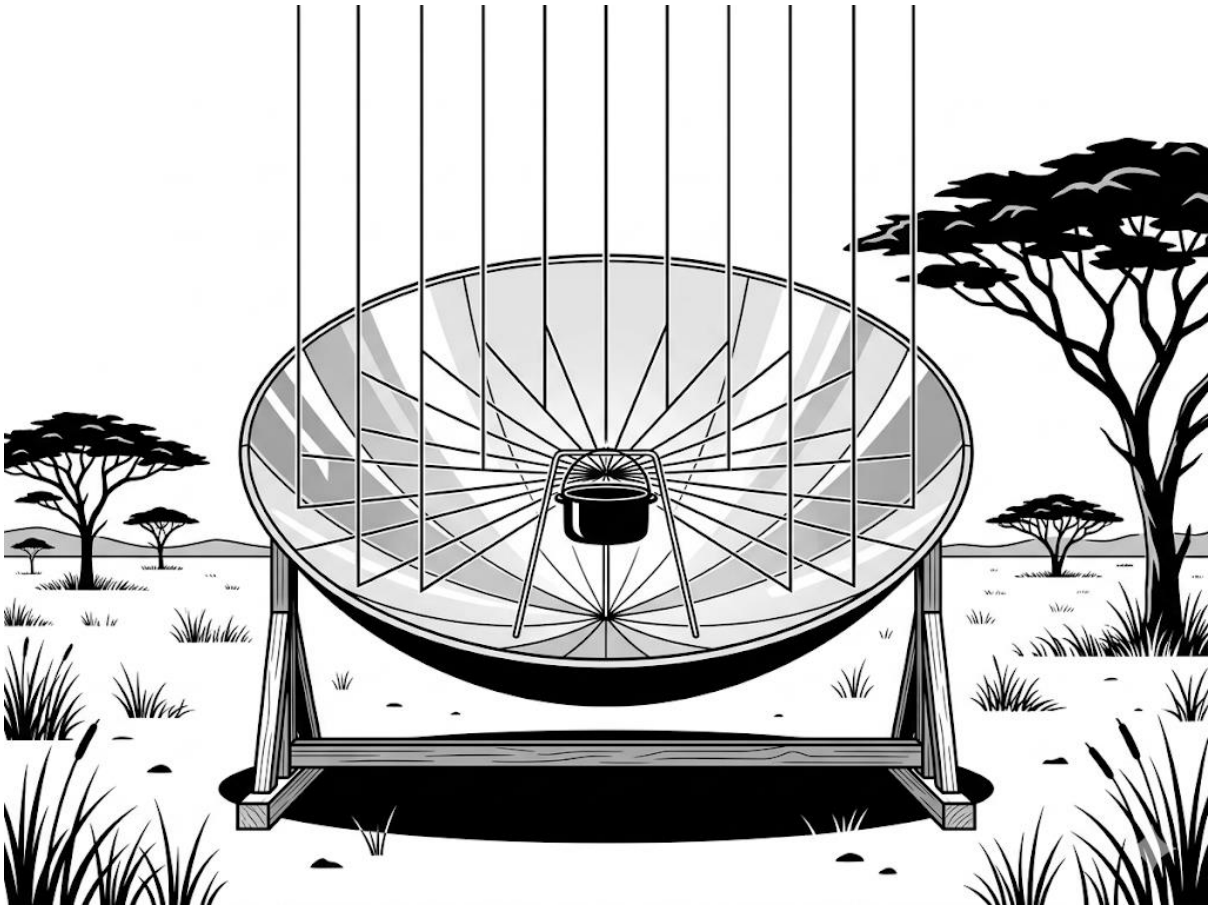
Task:

- (a) Using your knowledge of optics, justify to the village elders why a concave curved surface is the most suitable choice for a solar cooker compared to a plane or convex mirror.
- (b) Calculate the precise distance from the center of the curved aluminum sheet where Musa should place the cooking pot to ensure it receives the maximum possible heat. Include a ray diagram to support your explanation.
- (c) Identify two potential practical challenges Musa might face when using this solar cooker in an open field in Masaka and propose a scientific solution for each.
- (d)

2. Scenario

Mr. Okello's village in a sun-drenched part of Eastern Uganda is facing a severe shortage of firewood for cooking. A group of S5 Physics students from a nearby school suggests using solar energy as a sustainable alternative. The students have acquired two types of highly polished curved metal sheets: Type X, which bulges outwards towards the sun, and Type Y, which curves inwards like a deep bowl.

The village committee is unsure which metal sheet to use and where exactly to place the cooking pot to ensure the food cooks in the shortest time possible. Additionally, the students notice that when they use a very large spherical Type Y sheet, the "spot" of light on the pot appears blurred and spread out rather than being a sharp, hot point. This spread of light is reducing the temperature reached by the pot.



Task

As a student leader of the project:

- (a) Advise the committee on which metal sheet (Type X or Type Y) is suitable for the solar cooker, providing a clear scientific justification for your choice.
- (b) Describe the precise position where the cooking pot should be suspended relative to the mirror's surface. In your explanation, include a ray diagram to show how the sun's rays interact with the chosen surface.
- (c) Explain the cause of the "blurred light spot" observed with the large spherical sheet and suggest a specific modification to the shape of the reflecting surface to eliminate this problem and increase cooking efficiency.

3. Scenario:

In a remote village bordering Kidepo Valley National Park, the sun shines intensely for most of the year. To reduce the community's reliance on firewood, a local NGO provides a large, highly reflective concave mirror to be used as a solar cooker for the village school. Mr.

Lokiru, the headteacher, wants to mount a large cooking pot such that it receives the maximum amount of heat from the sun.

The NGO's manual is missing, and the focal length of the mirror is unknown. Mr. Lokiru knows that for the water in the pot to boil quickly, the pot must be placed exactly at the "hot spot" where all the sun's rays converge. He enlists a group of S5 Physics students to determine the focal length of the mirror and advise him on where to position the pot relative to the mirror's pole. **Task:**

- (a) With the aid of a ray diagram, explain why a concave mirror is the most suitable choice for Mr. Lokiru's solar cooker compared to a plane or convex mirror.

- (b) Describe an experimental procedure the students could use to determine the focal length (f) of the donated mirror using the method of No Parallax. Your description should include the required apparatus and the necessary precautions to ensure an accurate result.

- (c) Suppose the students successfully determined the focal length to be 40 cm. If Mr. Lokiru decides to use the mirror to create a magnified upright image of a small safety sign placed 25 cm in front of the mirror, calculate the position and magnification of this image. Comment on whether this setup would be effective for cooking.

