Bed of Nails

Keywords: Bed of Nails, Forces, Mechanics, Physics, Pressure

Meta Description

Discover the science behind a famous magic trick: lying on a bed of nails! Is it a trick after all?

Learning Objectives

Understanding the concept of pressure, particularly the relationship between pressure, area and force.

Key Terms

Bed of nails
A piece of wood with nails driven through it such that the sharp end of the nail protrudes upwards.

Pressure
Pressure (P) is defined as the force per unit area, mathematically calculated by the equation:

$P=F/A$ [*eq. 1*]
where F is the force applied and A is the area.

Method

Step 1
Take one of the wooden boards and drill 98 holes for the nails to be pushed through later on.

Step 2
Drill two larger holes on opposite sides of the wooden board, close to the edges, and glue the wooden dowels in the holes.

Step 3
On the other wooden board drill two holes matching the positions of the dowels attached to the first board such that the board can slide along the dowels.

Step 4
Insert the nails through the 98 holes in the board at the bottom and make sure they are all level.

Step 5
Place a balloon between the bed of nails and the upper wooden board and apply some pressure to the top board.

Step 6
Demonstrate that a large force needs to be applied in order to pop the balloon.

Precautions

1. The nails are very sharp and must be handled with great care.
2. When pressing down on the board, increase the force applied on the upper board slowly. Be careful that the boards do not slip to avoid your hands getting cut on the nails.
3. Leave the nails uncovered only when they are in immediate use.

Narrative

Once the bed of nails set-up has been prepared, blow up a clear balloon and show that the nails are sharp by popping the balloon with the leftover nail. Next, blow up another balloon and place it on the bed of nails. Slide the top board down the dowels and start pressing on the balloon. Show that the balloon does not pop easily, but keep pressing until it pops to show the audience there are no tricks involved, and that with enough force the balloon will still pop. Highlight that more effort was needed to pop the balloon when using the bed of nails than when a single nail was used.

Questions

Pressure depends on force and area. By increasing the number of nails, what is changing?
The area.

Pressure depends on force and area. By pressing harder on the balloon, what is changing?
The force.

Does increasing the force on the balloon increase or decrease the pressure?
Increase.

Are the nails sharp enough to burst the balloon?
Yes, this can be demonstrated by easily popping a balloon using one nail.

Why is it hard to pop the balloon on the bed of nails?
The force applied is distributed over a larger surface area, thus reducing the pressure on the balloon.

Will the balloon eventually pop on the bed of nails?
Of course, but significant pressure is required. Pressure is increased by increasing the applied force.

Brief Explanation

Theballoon can be easily popped using a single nail. This is because all the force applied to the balloon is effected on a very small area, thus resulting in a very large pressure being exerted on the balloon. By using more nails, the pressure points are spread over a larger surface of the balloon and thus the force exerted on the balloon is spread out over a larger area. This drastically reduces the pressure produced by each individual nail and makes the balloon much harder to pop.

Detailed Explanation

The pressure exerted can be described by the equation:

$$P=FA \qquad [eq.\ 1]$$

where$P$is the pressure,$F$is the force applied and$A$is the area.

Equation [1] implies that for a constant area, pressure is directly proportional to the force applied meaning that the harder the balloon is pushed down, the higher the pressure exerted on the balloon from the nails.

Equation [1] also suggests that if the force applied is constant, the pressure is inversely proportional to the area. This is precisely what is happening in this demonstration. Since it is the pressure which makes the balloon pop, by increasing the number of nails, the force is distributed over a larger area which reduces the pressure exerted on the balloon. This reduced pressure is not large enough to pop the balloon, and the pressure is increased by increasing the force exerted on the balloon. Eventually, the pressure is large enough to pop the balloon.

Applications and Research

Applications

The relationship between pressure, force and area is used in many different applications. For example, needles used to inject drugs into the human body have a very small area so that they can puncture the skin with ease. Conversely, a snowshoe is designed to increase the surface area in contact with the ground. This reduces the pressure and makes it easier to walk on soft snow.

Research

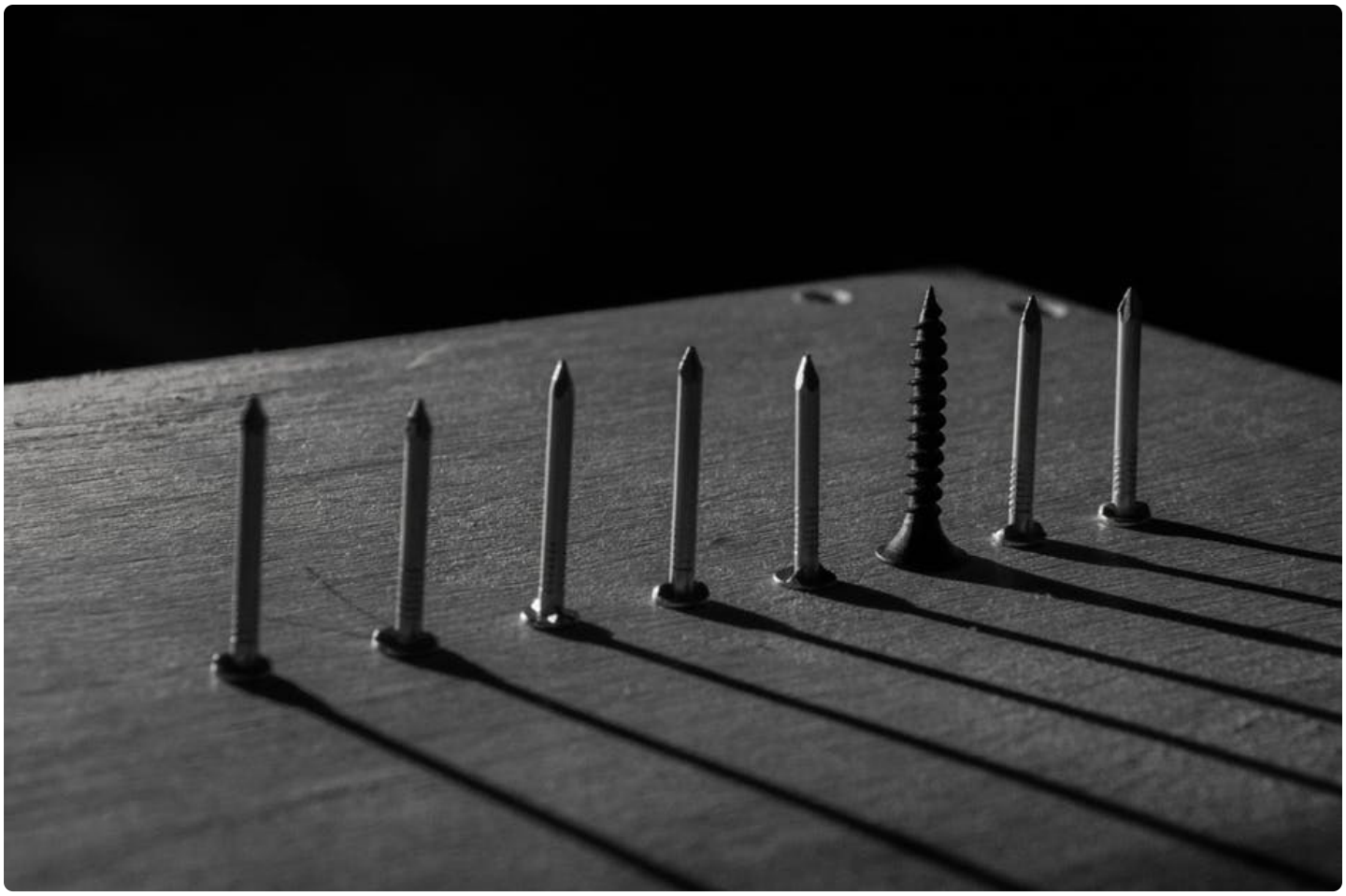
The concept of pressure is fundamental in architecture and civil engineering. The foundations of a building experience intense pressure for prolonged periods of time, but must remain safe and structurally sound in order to support a building throughout its lifetime. There is ongoing research to optimise and improve building foundations and thus avoid faults developing over the years.

Investigation

Altering the number of nails used varies the effective area over which the force is exerted on the balloon. An investigation could be carried out by applying a constant weight on the balloon and finding out the minimum number of nails required to make the balloon pop. This can be done by placing a fixed weight on the wooden board, say two heavy books or a known weight, and removing nails one at a time from the bed. In each test a nail would be systematically removed from the board, and the weight then placed on the board.

In this investigation more than one balloon is needed and so it is important to use the same type of balloons. The balloons should also be inflated with the same amount of air.

Besides varying the number of nails, the experiment could be performed using nails of different sizes.



Subject

Physics

Education

Secondary
Post Secondary
University
Informal

Time Required

~45 minutes
Preparation: 30 minutes
Conducting: 5 minutes
Clean Up: 10 minutes

Cost

10 – 25 €

Recommended Age

10 – 12
13 – 16
>16

Number of People

1 participant

Supervision

Required

Location

Indoors
Outdoors
Festivals
Laboratory

Materials

Clear balloons

Drill

Drill bits: one which has a similar size to the nails used and one which has a similar size to the diameter of the wooden dowels.

99 nails

2 wooden boards

2 wooden dowels

Contributors

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Sources

Bed of Nails: Table Top Variation

Pressure: Bed of Nails

Additional Content

Bed of Nails – Table-Top Variation (Beginners)

Pressure (Beginners)

Pressure (Intermediate)

Pressure Calculations (Intermediate)

The use of ultrasonic measurements under modest pressure to estimate compression at high pressure (Advanced)

The succulent science of pressure cooking (Advanced)

Cite this Experiment

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