

Pressure

Unit: Pressure & Fluid Mechanics

NGSS Standards: N/A

MA Curriculum Frameworks (2006): N/A

AP Physics 2 Learning Objectives: 3.4.C.1, 3.4.C.2

Knowledge/Understanding:

- pressure

Skills:

- calculate pressure as an applied force

Language Objectives:

- Understand and correctly use the term “pressure” as it applies to situations in physics.
- Accurately describe and apply the concepts described in this section using appropriate academic language.
- Set up and solve word problems relating to pressure and hydraulics.

Labs, Activities & Demonstrations:

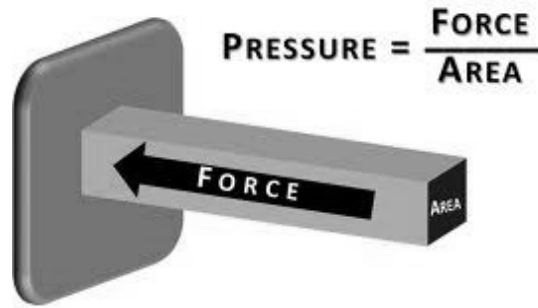
- Balloon.
- Pinscreen (pin art) toy.
- Balloon & weights on small bed of nails.
- Full-size bed of nails.

Notes:

pressure: the exertion of force upon a surface by an object, fluid, *etc.* that is in contact with it.

Use this space for summary and/or additional notes:

Mathematically, pressure is defined as force divided by area:



$$P = \frac{F}{A}$$

The S.I. unit for pressure is the pascal (Pa).

$$1 \text{ Pa} \equiv 1 \frac{\text{N}}{\text{m}^2} \equiv 1 \frac{\text{kg}}{\text{ms}^2}$$

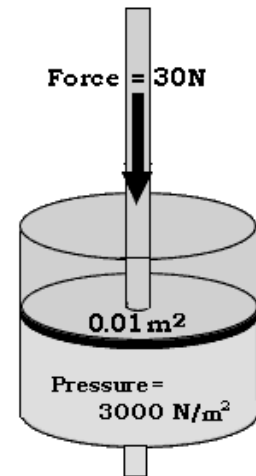
(Note that Pa is a two-letter symbol.)

Some other common pressure units are:

- bar: $1 \text{ bar} \equiv 100000 \text{ Pa} \equiv 10^5 \text{ Pa}$
- pound per square inch (psi)
- atmosphere (atm): the average atmospheric pressure on Earth at sea level.

$$1 \text{ atm} \equiv 101325 \text{ Pa} \equiv 101.325 \text{ kPa} \equiv 1.01325 \text{ bar} = 14.696 \text{ psi}$$

We will use the approximation that $1 \text{ atm} \approx 1 \text{ bar} = 100000 \text{ Pa}$



Air pressure can be described relative to a total vacuum (absolute pressure), but is more commonly described relative to atmospheric pressure (gauge pressure):

- absolute pressure: the total pressure on a surface. An absolute pressure of zero means there is zero force on the surface.

Use this space for summary and/or additional notes:

- gauge pressure: the difference between the pressure on a surface and atmospheric pressure. A gauge pressure of zero means the same as atmospheric pressure. The pressure in car tires is measured as gauge pressure. For example, a tire pressure of 30 psi (30 pounds per square inch, or $30 \frac{\text{lb}}{\text{in}^2}$) would mean that the air inside the tires is pushing against the air outside the tires with a pressure of 30 psi. A flat tire would have a gauge pressure of zero.

Sample Problem

Q: What is the pressure caused by a force of 25 N acting on a piston with an area of 0.05 m^2 ?

A:
$$P = \frac{F}{A} = \frac{25 \text{ N}}{0.05 \text{ m}^2} = 500 \text{ Pa}$$

Homework Problems

1. A person wearing snow shoes does not sink into the snow of the tundra, whereas the same person without snow shoes sinks into the snow. Explain.

2. A balloon is inflated to a pressure of 0.2 bar. A 5.0 kg book is balanced on top of the balloon. With what surface area does the balloon contact the book? (*Hint: Remember that 1 bar = 100 000 Pa.*)

Answer: 0.0025 m^2

Use this space for summary and/or additional notes:

3. A carton of paper has a mass of 22.7 kg. The area of the bottom is 0.119 m^2 . What is the pressure between the carton and the floor?

Answer: 1908 Pa

4. A 1000 kg car rests on four tires, each inflated to 2.2 bar. What surface area does *each* tire have in contact with the ground? (Assume the weight is evenly distributed on each wheel.)

Answer: 0.0114 m^2

5. A student with a mass of 75.0 kg is sitting on 4-legged lab stool that has a mass of 3.0 kg. Each leg of the stool is circular and has a diameter of 2.50 cm. Find the pressure under each leg of the stool.
(Hints: (1) Remember to convert cm^2 to m^2 for the area of the legs of the stool. (2) Remember that the stool has four legs. (3) Note that the problem gives the diameter of the legs of the stool, not the radius.)

Answer: 397250 Pa

Use this space for summary and/or additional notes:

6. A student with a mass of 50. kg is lying on the floor of the classroom. The area of the student that is in contact with the floor is 0.6 m^2 . What is the pressure between the student and the floor? Express your answer both in pascals and in bar.

Answer: 833 Pa or 0.00833 bar

7. The same student, with a mass of 50 kg, is lying on a single nail has a cross-sectional area of $0.1 \text{ mm}^2 = 1 \times 10^{-7} \text{ m}^2$. What is the pressure (in bar) that the student exerts on the head of the nail?

Answer: $5 \times 10^9 \text{ Pa} = 50000 \text{ bar}$

8. The same student, with a mass of 50 kg, is lying on a bed of nails that contains 2500 nails evenly spread over an area of 0.84 m^2 . If the student is in contact with 1800 of the nails, what is the pressure (in bar) between the student and each nail?

Answer: 28 bar

Use this space for summary and/or additional notes: