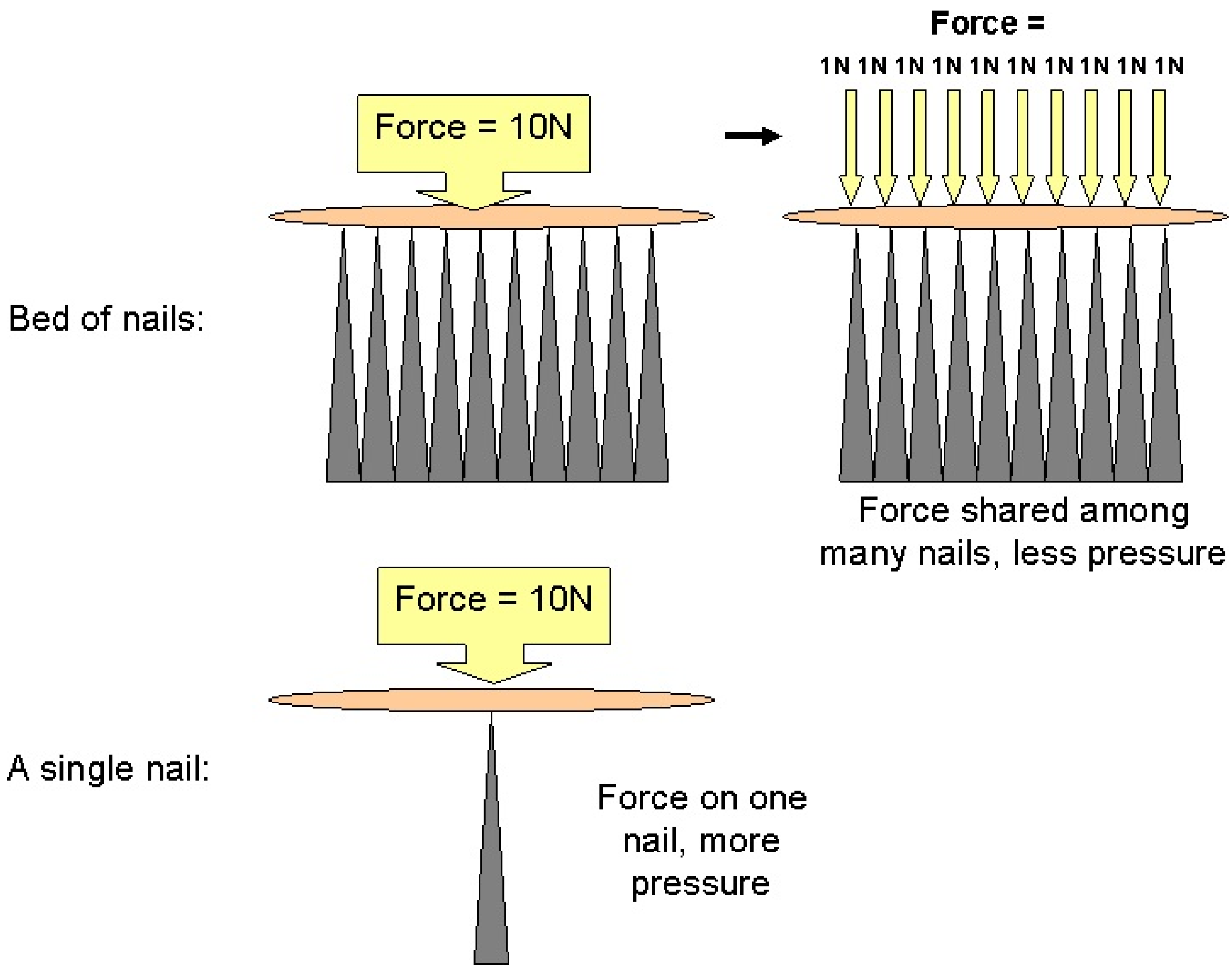
How Much Pressure Can You Stand?

The reason you don't end up like a human sieve on a bed of nails is that there are *so many* nails supporting your weight - each individual nail is only supporting a tiny bit of your weight. So there's not enough pressure at each contact point to poke a hole in you. If you were lying on *fewer* nails, your weight would be shared by *fewer* contact points and there would be *more pressure* at each point. Of course the pressure of your weight on a *single* nail would be far too great for your tender skin to bear!



What exactly does '**pressure**'mean in this context? Let's compare it to normal usage in English. If you are under a lot of pressure from work, it probably means that you have too much work to do. It would be nice if one of your friends could help you do some of it - there would be less pressure because there would be two people sharing the load.

In physics, pressure measures the amount of force that is on a certain area of space. If there is more area to share the force, then there is less pressure. Stand up and do this: stand on *both feet*, then stand on *one foot*, then stand on your *toes*, finally stand on just *one big toe*. Can you do that? Probably not so well on your big toe! Did you feel more and more pressure as you stood on less and less area?

Knowing this, we can easily *decrease the pressure* exerted by a force - simply by *increasing the area* that the force is acting on. We do this when we wear snowshoes to keep from breaking through the snow. We can also *increase pressure* - by *decreasing the area* that the force is acting on. We can't break through a bulletin board with our hand, but we can easily do so with a tiny thumb tack

Calculating Pressure

To calculate pressure, we take the *amount of force* exerted and divide it by the *area* the force is acting on. This gives us the amount of force on one unit of area. That is what we call '**pressure**'-*the amount of force per unit area*.

We are going to use a unit for pressure called **pascal (P),** named after a French scientist who studied fluids. In a pascal, the unit of area is one *metre squared*; that is the area you get if you took four metre sticks and made a square. In a pascal, the force applied on the area is given in *newtons*. Since one pascal is a very small amount of pressure, we often talk about pressure in kilopascals; one *kilo*pascal equals *one thousand* pascals.

Properties of Fluids

Pressure: the amount of force per unit area

one pascal of pressure = a force of one newton acting on an area of one metre squared

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} \qquad P = \frac{F}{A}$$

Pressure Calculation: Summary of Units and Symbols

	symbol	unit	calculation
pressure	p	pascal (Pa), kilopascal (kPa)	$P = \frac{F}{A}$
force	F	newton (N)	$F = pA$
area	A	m^2	$A = \frac{F}{P}$

Exercise:

What pressure does a 3 000 kg truck exert on a rectangular surface measuring 2.0 m by 1.5 m?

Given: m = 3000 kg, l = 2.0 m, w = 1.5 m, g = 9.8 N/kg

Find: P

Solution:

1. Find the Area

A = l x w
= 2.0 m x 1.5 m
= 3.0 m^2

2. Find the Force

Force = Force of Gravity (F_g)
F_g = m x g
= 3 000 kg x 9.8 N/kg
= 29 400 N

3. Find the Pressure

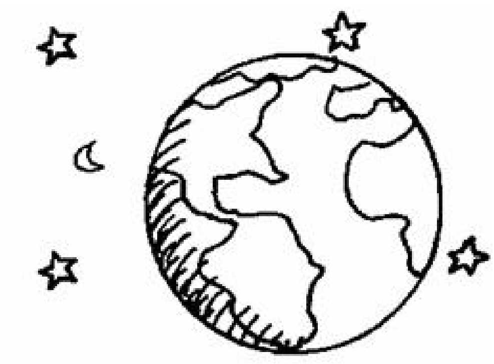
P = F/A
= 29 400 N / 3. 0 m^2
= 9 800 Pa
= 9.8 kPa

Pressure of Our Atmosphere

Most of the mass of the air (about 75%) is in the bottom 10 km of the atmosphere. The closer to the ground we are, the greater the pressure; this is because each layer of air is pressing on the layer below it.

Imagine being at the bottom of a human pyramid, like the acrobatic feats that cheerleading teams perform. The person at the bottom experiences a lot more pressure than the lucky one on top. The lower layers of air are more 'squished together', forcing the molecules closer together.

The atmospheric pressure at 'sea level', at 25Â°C, is 101.3 kPa. As you climb higher, the atmospheric pressure drops quickly. At about 3 km above sea level, the pressure is only about 67 kPa. This tells us that there are *fewer molecules* in the air - the air is 'thinner'.



At this altitude, people have trouble getting enough oxygen; they suffer symptoms of 'altitude sickness' - headache, shortness of breath, and nausea. Athletes who compete at high altitudes train in those conditions to accustom their bodies to the reduced oxygen.

Athletes can also take advantage of the thinner air. Records have been set for baseball and football in locations such as Denver, Colorado; since there is less air to move through, the ball can go a lot farther. Of course the hitter and the quarterback are breathing less oxygen too! So maybe it all evens out.

Our planet Earth is covered by a blanket of air over 100 km thick. That is a very fortunate thing for us - it is the precious air that we breathe, and we want to take good care of it. Not all planets have this layer of air which we call our atmosphere; most planets have no atmosphere, which is not to say that they're not fun places to visit.With our life-sustaining atmosphere, comes pressure - **atmospheric pressure**. That is the weight of the thick blanket of air pressing down on each square metre of area on everything in Earth. Do you feel that weight? You can't see the invisible air, but there is a column of it over 100 km tall, sitting right on top of your head. Air can't weigh very much, can it? Does it weigh anything at all? Each molecule in the mixture we call air is pulled by gravity toward the Earth. Each molecule doesn't weigh much, just as a molecule of water doesn't weigh much, but when you sit under water, even a few metres deep in a swimming pool, you can feel the pressure of that water on your body. We don't feel the pressure on our bodies, even though it is a lot of pressure. If we had to lift the column of air on top of our heads, it would be over 200 kg of weight. Even the strongest of weight-lifters would find that a challenge, but we do it every minute of everyday. Well, we are used to it, and the same pressure is acting *all around us* and *inside and outside of us*. You notice the difference in pressure when your ears 'pop' if you change your altitude quickly - on a plane or down a hill. Also, since air is a fluid, we *move through it* the way we move through water - we don't actually *lift* the water above our heads - all the little fishies would have to be awfully strong.

Atmospheric

Pressure at **Work**

2. Get a drinking glass from the kitchen cupboard or an empty glass jar from the recycle bin. It has to be made of glass and without a spout; any height is fine, but a narrower mouth would be best.

4. Get ready a piece of paper or thin cardboard big enough to cover the entire mouth of the glass container.

6. Fill the glass container right to the top with water, almost overflowing.

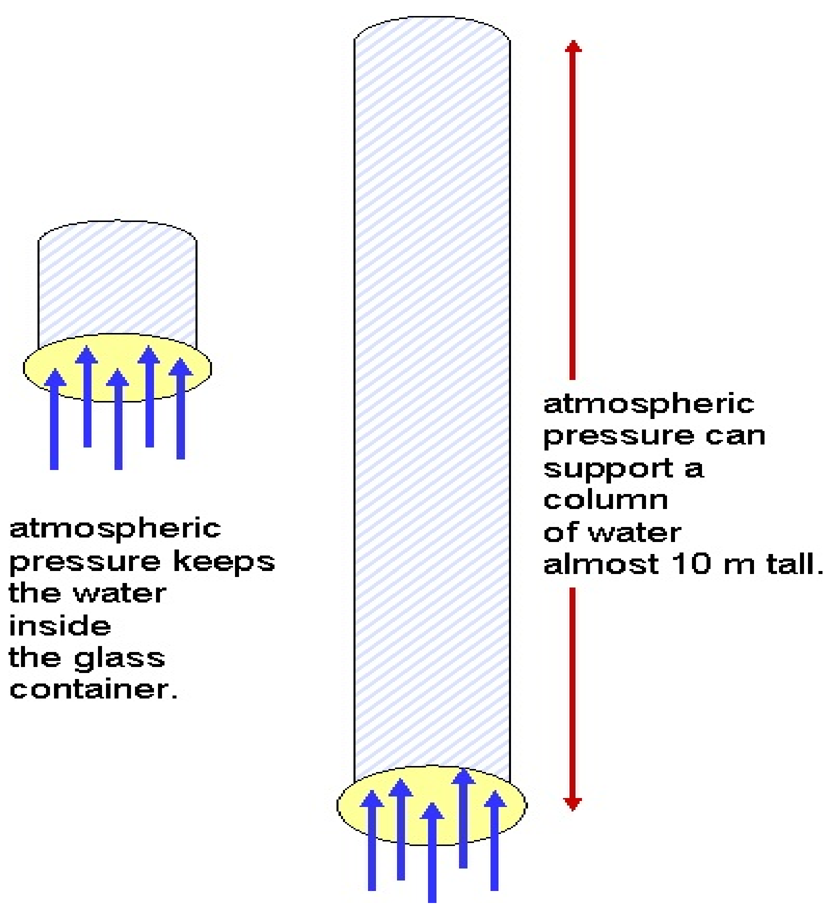
8. Carefully place the piece of paper or cardboard on top of the water in the container so that it touches the rim all the way around.

10. Hold the container with one hand and flip the container upside down - no need to panic or rush. Hold over the sink if you're not confident.

12. The water should stay inside the container! If you don't succeed the first time, try again, or use a glass with narrower mouth.

Questions:

1. What is holding the water up?
2. How much water can be held in the upside-down container without pouring out



Answer the following questions:

1. Define the scientific term "pressure"; give the proper units and mathematical (formula) definition.
2. All pointed objects and tools such as nails, awls, screws, needles, etc., make use of the scientific definition of "pressure" you stated above. Explain in your own words, using this knowledge, how these instruments work.
3. Complete the following table:

pressure (Pa or kPa)	**force** (N)	**area** (m^2)
	300	20
20 kPa	1000	
540		225

Question #1: Answer

Answer the following questions:

1. Define the scientific term "pressure"; give the proper units and mathematical (formula) definition.

Pressure is defined as the amount of force exerted over a given area.
The units of pressure are Pascals (Pa) or kilo Pascals (kPa).
The mathematical formula to calculate Pressure is P = F/ A (Force per Unit Area).

2. All pointed objects and tools such as nails, awls, screws, needles, etc., make use of the scientific definition of "pressure" you stated above. Explain in your own words, using this knowledge, how these instruments work.

Sharp tools and pointed objects, in general, are used to cut or penetrate a relatively hard material. These tools make use of the fact that pressure increases when force is applied over a smaller area. The sharper the object, the greater the penetrating power (pressure) it has.

Complete the following table:

pressure (Pa or kPa)	**force** (N)	**area** (m^2)
P = F / A = 300 N / 20 m^2 =15 Pa	300	20
20 kPa	1000	A = F / P = 1000 N / 20 000 Pa = 0. 00 m^2
540	F = P x A = 540 Pa x 225 m^2 121 500 N	225