

Feel the Pressure

The depth of footprints produced while walking along the beach is due to the pressure exerted on the sand by your feet. Pressure is a measure of the force exerted by an object (its weight) as it is spread out along the surface.



- Examine the sets of footprints in the picture. What inferences can you make about the two people who made the footprints?

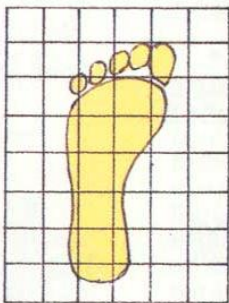
- Provide an explanation how snowshoes allow you to walk on top of the snow?



PART I: DETERMINING FOOT PRESSURE

In this part of the experiment you will determine the pressure on the soles of your feet by measuring the surface area of your feet (in square inches) and your weight (in pounds). You will then rank and compare your results with your classmates to determine if the pressures are similar or different.

1. Use the bathroom scale to measure your weight (in pounds). No cheating!! _____ (lbs)



2. Remove one of your shoes and place one foot on the 1 inch x 1 inch grid while standing. Use a pencil to sketch an outline of your foot. (Make sure to get under the arch since you want only the portion of the foot in contact with the floor).

3. Estimate the surface area your footprint:

Step 1: Number the complete squares that lie within the sketched outline.

4. Combine partial squares together to form approximate complete 1 inch squares. Number these as well.

Area of both feet: _____ (in²)

5. Calculate the pressure (pounds per square inch) while standing on **both** feet. (Remember you have two feet!) Show your work below and record your answer to one decimal place by either rounding up or down. Write your name and pressure on the board.

$$\text{Pressure} = \frac{\text{Weight (lbs)}}{\text{Area (in}^2\text{)}}$$

- After all of the foot pressures have been written on the board, compare the values. Are they similar in value or different?

PART II: DETERMINING ANKLE PRESSURE

Your foot acts to spread out your body weight decreasing the pressure on your feet as you walk, much like what snowshoes do. In this portion you will determine the pressure on the bones in your ankle.

- Use the tape measure and measure the circumference of your ankle directly above the ankle joint.

Ankle Circumference: _____ (in)

To determine the area, we must know the relationship between the circumference of a circle and the area of a circle. The circumference of a circle is equal to $2 \pi r$, while the area of a circle is equal to πr^2 .

- Knowing the circumference of your ankle, the formula can be rearranged to calculate the radius of your ankle. Show your work.

Radius = Circumference / 2π

Ankle Radius: _____ (in)

- Knowing the radius you can calculate the cross sectional area of your ankle. Show your work.

Area = πr^2

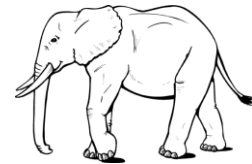
Ankle Cross Section Area: _____ (in²)

- Calculate the pressure for **both** ankles. Show your work.

Ankle Pressure: _____ (lbs/in²)

PART III: HUMANS VS OTHER ANIMALS

Zoologists who study animals in the wild and in captivity collect data on young and adult animals to determine their age, health, and developmental changes. The following data was obtained from the Indianapolis Zoo:



Elephant Name	Gender	Age (years)	Weight (lbs)	Circumference (in)	Foot Radius (in)	Area (1 foot) (in ²)	Area (4 feet) (in ²)	Pressure (4 feet) (lbs/in ²)
Amali	Female	2	1500	28				
Sophi	Female	33	9300	52				

- The adult elephant is almost 6 times the weight of the young elephant. Is the foot pressure of the adult 6 times that of the young elephant? Provide a reason why the pressures are different for young and old elephants.
- What might you infer about the differences in pressures for young and old humans?
- How does the pressure on your ankle compare with the pressure on an elephant's foot?



➤ Polar bears live only in the arctic and are the world's largest land carnivores. Data obtained from the Indianapolis Zoo for an adult male polar bear **weighs 1200 lbs** with a **foot circumference of 34 inches**.



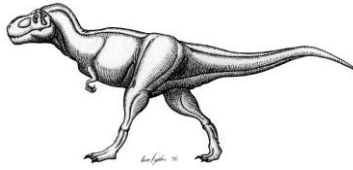
Determine the foot pressure of the polar bear.

Polar Bear Pressure: _____ (lbs/in²)

- How does your foot pressure compare with the foot pressure of a polar bear?
- Suggest a reason why the foot pressure of the polar bear is much lower than that of the elephant? (Hint: Where does it live?)

PART IV: MAKING INFERENCES TO OTHER ANIMALS

Archeologists have found footprints of dinosaurs that lived millions of years ago that have been preserved in mud. This data provides crucial evidence in determining the size, weight, and behavior of these extinct animals.



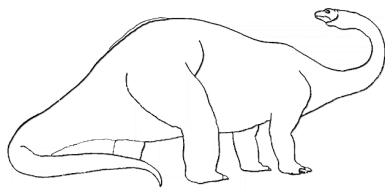
Tyrannosaurus Rex, lived approximately 65 million years ago, walking upright on two massive hind legs. T. Rex was one of the largest land carnivores, measuring around 40 feet long and weighing on average of 10,000 lbs. The three-toed, triangular footprints have been located in New Mexico and Montana that measured **28" wide and 33" long**.

- Using the formula for determining the area of a triangle (**Area = $\frac{1}{2}$ width x length**), determine the area of both T. Rex's feet and its foot pressure.



Foot Pressure: _____ (lbs/in²)

- T. Rex is comparable in weight to the elephant, however, an elephant walks on four legs and T. Rex walks on two legs. Is the total surface area of their feet similar or very different? What is the average surface area of one elephant foot versus one T. Rex foot?



Apatosaurus, formerly known as Brontosaurus, was one of the largest dinosaurs that lived approximately 140 million years ago. On average, it was 75 feet long and 50,000 lbs! Apatosaurus was a herbivore that used its massive tail as a counterweight to balance its long neck. Fossilized footprints have been found in Colorado, measuring 24" wide by 33" long.

- Using the formula (**Area = width x length**) for the surface area of the Apatosaurus' foot, calculate the pressure on each foot.

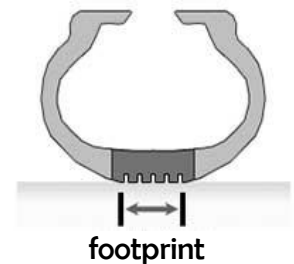
Foot Pressure: _____ (lbs/in²)

- In comparing the two dinosaurs, why would it be advantageous for a carnivore to have a smaller foot pressure than a herbivore?

POST LABORATORY QUESTIONS

1. Provide the three formulas you used to determine area in this laboratory.
2. An elephant's foot measures 17.5 inches in circumference and weighs 1200 lbs. What is the pressure on the bottom of the elephant's foot?

3. My car has a GVW (Gross Vehicle Weight) of 3400 lbs. Using a method similar to determining the area of my foot, I parked my car on top of a piece of paper and traced the area of the tire in contact with the ground. The tire print formed an impression that measured 6 inches long by 5 inches wide. I also noticed that the recommended tire pressure in my tires is 30 lbs/in². Compare the air pressure inside the tire with the pressure of the tire on the ground. Is there something I did not account for when I measured the "footprint" of my tire? How did this error affect the calculated pressure of the tire on the ground?



4. As we have demonstrated, adult humans have a foot pressure between 2.5 lbs/in² and 3.5 lbs/in². A 6 year-old boy has a weight of 75 pounds while each foot has a surface area of 16 in². How does the pressure on child's foot compare with an average adult's pressure? Can you provide a possible explanation for your results?