THE MYSTERIOUS GRAY KNIGHT

MARC HATED BABYSITTING AFTER SCHOOL.

HE'D RATHER BE HANGING OUT WITH FRIENDS.

But Marc's five-year-old cousin Stetson felt differently. As Marc approached Stetson's house, he could see the little boy at the window excitedly waiting for him.

As Marc came inside, Stetson opened his hand to show a toy knight Aunt Claire had found in the attic. The knight was painted, but where the paint had worn off, it was gray.

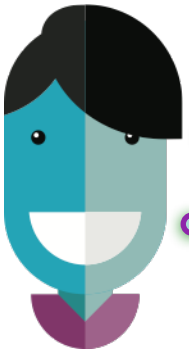
Marc, tell me a story about this man! Stetson demanded.

MARC DID NOT WANT TO THINK UP A STORY FOR HIS COUSIN, BUT HE SAID,

"Well let me see him."

MARC WAS SURPRISED THAT THE KNIGHT FELT HEAVY — MUCH HEAVIER THAN PLASTIC TOY SOLDIERS OF A SIMILAR SIZE. MARC TOLD STETSON A STORY ABOUT A KNIGHT WHO DID NOT WANT TO FIGHT A BATTLE... BUT WHILE TELLING THE STORY...

MARC KEPT WONDERING...



Why does the knight feel so heavy, and what is it made of?

Hmmm. Maybe I can weigh the knight.

MARC FOUND A SCALE IN AUNT CLAIRE'S CUPBOARD, BUT IT ONLY WEIGHED THINGS IN OUNCES.

In science class we always use grams, but I can figure out how to change ounces into grams later.

THE KNIGHT WEIGHED VERY CLOSE TO 7.5 OUNCES.

I wonder what else I need to know to figure out what the knight is made of?

WHAT IS MARC'S BIG QUESTION?

*WHAT IS MARC'S FIRST TESTABLE QUESTION?

WHAT IS THE ANSWER TO MARC'S FIRST TESTABLE QUESTION?

WHAT ELSE DOES MARC NEED TO KNOW TO FIND OUT WHAT I AM MADE OF?

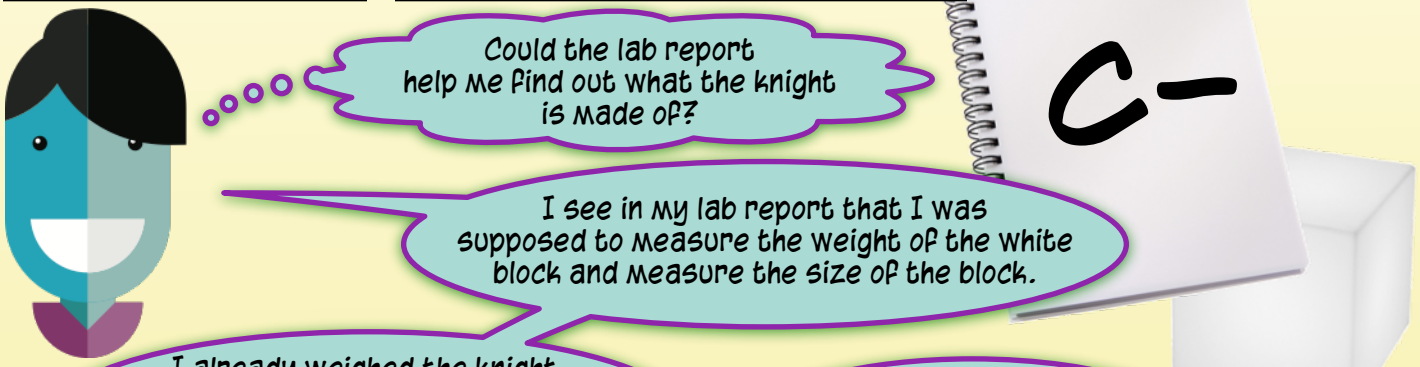
*A TESTABLE QUESTION CAN BE ANSWERED WITH AN SCIENCE INVESTIGATION

THE NEXT DAY AT SCHOOL,

MARC'S SCIENCE TEACHER RETURNED THE STUDENTS' LAB REPORTS.

MARC'S C- GRADE ON THE REPORT SHOWED THAT HE HADN'T CARED MUCH ABOUT FINDING OUT WHAT A WHITE MYSTERY BLOCK WAS MADE OF.

BUT SOMETHING ABOUT THE WHITE BLOCK EXPERIMENT REMINDED MARC OF STETSON'S KNIGHT.



Could the lab report help me find out what the knight is made of?

I see in my lab report that I was supposed to measure the weight of the white block and measure the size of the block.

I already weighed the knight, but measuring the size of the knight seems hard because the knight is not a regular shape like a block.

Maybe my science teacher can help me figure it out.

THE NEXT DAY, MARC SHOWED HIS SCIENCE TEACHER THE MYSTERIOUS KNIGHT.

Do you know what the knight is made of?

INSTEAD OF ANSWERING, THE TEACHER STARTED TO ASK MARC QUESTIONS:

Where did you find the knight?

What do you think it is made of?

Marc remembered that his teacher seemed to be big on making predictions, so Marc guessed that the teacher wanted him to make a prediction.

I don't know what to predict, but...

I think the knight is made of something heavy, and

... it weighs close to 7.5 ounces ...

... But, I don't know what that means.

Can I use the knight during science class tomorrow?

I can help you figure it out!

THE NEXT DAY, MARC'S TEACHER HELD UP THE KNIGHT IN CLASS. HE PASSED IT AROUND AND LET THE STUDENTS OBSERVE IT.

What questions do you have about the knight?

I want to know What the knight is made of!

I think it is a metal because its gray and heavy!

What type of metal could it be? How could you find out?

It isn't gold metal because its not colored yellow!

Color IS a property that's unique to a material. Color can be used to distinguish one material from another!

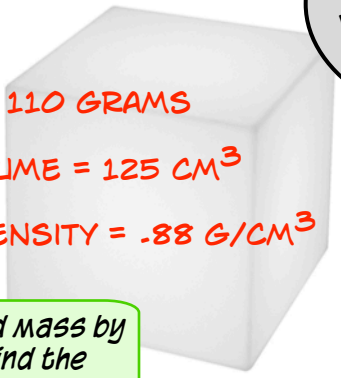
Other properties can be used to identify materials.

We found how heavy the block was by weighing it.

Think back to the mystery block experiment.

What were you finding out about the white blocks?

True, but "heavy" could also mean how dense something is.



Yeah, we measured the volume of the block

and we divided mass by volume to find the density.

THE CLASS AGREED THAT IN THE MYSTERY BLOCK EXPERIMENT THEY HAD CALCULATED THE DENSITY OF THE BLOCK USING THE WEIGHT (MASS) AND THE VOLUME.

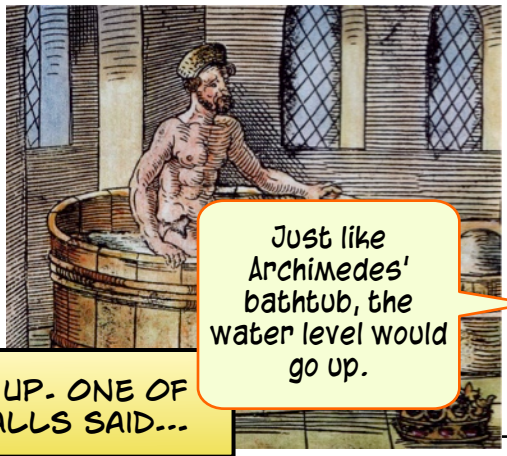
Finding the density of an object can help identify what it is made of.

I already found the weight on my Aunt's little scale.

But, I'm really curious about how to measure the volume.

THE CLASS PLANNED TO FIND BOTH THE MASS AND VOLUME OF THE KNIGHT AND THEN CALCULATE ITS DENSITY. THE STUDENTS SAID THEY COULD MEASURE MASS ON THE BALANCE.

THE NEXT DAY IN SCIENCE CLASS ---



What would happen if there was water in a beaker and the knight was placed into the water?

SEVERAL HANDS SHOT UP. ONE OF THE CLASS KNOW-IT-ALLS SAID...

Just like Archimedes' bathtub, the water level would go up.

What would you measure about the water in the beaker?

You measure the volume marking of the water before the knight is in the beaker.

Then you measure the volume marking after the knight is placed in the beaker.

What does the change in volume marking represent?

Hey! Now I know what the change in volume marking means...

The change in water volume is exactly the volume of knight!

You've got it! Class, let's do this.

I think the knight will fit in a graduated cylinder.

The ancient Greek scholar Archimedes is said to have exclaimed "Eureka!" when he stepped into a bath and noticed that the water level rose. He suddenly understood that the volume of water displaced by an object must be equal to the volume of the object. He is said to have been so eager to share his discovery that he leapt out of his bathtub and ran through the streets naked.

WHAT ARE THE BIG QUESTIONS MARC'S CLASS HAS ABOUT ME?

WHAT ARE THE TESTABLE QUESTIONS MARC'S CLASS HAS ?

THE RESULTS ...

FOUR GROUPS IN THE CLASS WEIGHED STETSON'S KNIGHT AND REPORTED WEIGHTS IN THE FOLLOWING TABLE.

WHAT WEIGHT OF ME DID THE CLASS FIND?

Group Number	Weight of Stetson's Knight
#1	213 g
#2	215 g
#3	374 g
#4	210 g

FOUR OTHER GROUPS OF STUDENTS PLACED THE KNIGHT IN A GRADUATED CYLINDER WITH WATER. THEIR MEASUREMENTS ARE RECORDED IN THE TABLE BELOW.

WHAT VOLUME OF ME DID THE CLASS FIND?

Group Number	Initial Water Height	Final Water Height
#5	50.0 mL	74.5 mL
#6	52.7 mL	78.5 mL
#7	46.0 mL	70.0 mL
#8	41.3 mL	67.0 mL

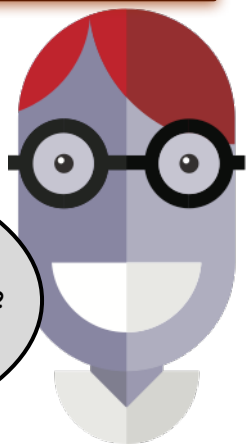
WHAT DENSITY OF ME DID THE CLASS FIND?

I am not sure how knowing the density of the knight helps tell what the knight is made of.

Can you explain?

Very good question, Marc!

We need to find out what the density of some common known metals or metallic materials are and then compare them to the density of the knight.



MARC'S TEACHER HELPS THE STUDENTS FIND A TABLE OF METALS AND PROPERTIES ...

SCIENTISTS RECORD DENSITY USING THE UNIT CM3 FOR VOLUME INSTEAD OF ML. 1 ML = 1 CM3

Metal or material	Density	Melting Point	Color
Gold	19.3 g/cm^3	1064 C	Yellow Gold
Copper	8.94 g/cm^3	1085 C	Orange Gold
Lead	11.34 g/cm^3	327 C	Gray
Tin	7.3 g/cm^3	232 C	Gray
Brass	8.4-8.7 g/cm^3	900-940 C	Gold
Stainless steel	7.9-8.03 g/cm^3	1400-1450 C	Gray
63/37 Tin/Lead Solder	8.40 g/cm^3	183 C	Gray

LOOKING AT THE DENSITIES ON THE CHART AND MY DENSITY, WHAT EVIDENCE IS THERE THAT I AM MADE OF PURE LEAD?

WHAT CLAIM CAN MARC AND HIS FELLOW STUDENTS MAKE ABOUT WHAT I COULD BE MADE OF?

WHAT EVIDENCE AND REASONING SUPPORTS THEIR CLAIMS?

I see that the densities of brass and stainless steel are not listed as only one value but as a range of values.

Why is that?

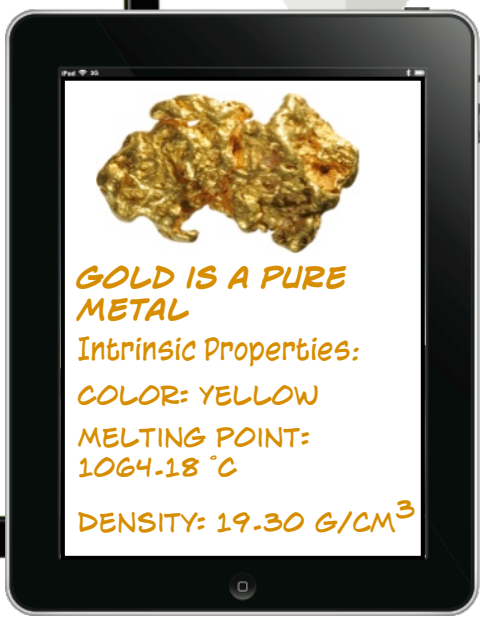
Great question! Let's read about it together!

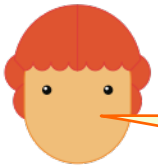
Some metallic elements are known as **pure metals.** Pure metals have densities of one specific value. Density, melting point and color are examples of intrinsic properties. All samples of a pure metal have the same intrinsic properties.

Some metals form alloys. Alloys are mixtures of different elements. For example, brass is an alloy that can be a mixture of the metal copper and different amounts of other metals such as tin or zinc. The density of the alloy depends on the metals used and the specific amount of each one.

Brass made with 55% copper and 45% zinc has one density. Brass made with 88% copper and 10% zinc has a different density. That's why brass has a range of density values.

Another alloy is 63/37 tin/lead solder. It is a mixture of 63% tin and 37% lead. This mixture melts at a lower temperature than either of the pure metals it contains.





I heard that lead was dangerous and toxic!

What if we touched some lead?

Will we get poisoned?

This metal knight is an old toy, and it may contain some lead.

These days, we know toys containing lead aren't safe for young children who still put objects in their mouths.

But, people still handle and use lead sinkers and shot for fishing and hunting.

Touching lead metal is not a big risk for us, although it is a problem for wildlife that eat it.

Washing your hands after handling lead is important!

Developed by *Fighting with Food* through Funding from SEPA Grant number R25 OD011090