

1 01:00:47:09 01:00:48:20 WOMAN:  
Measurement is the process

2 01:00:48:22 01:00:51:22 of quantifying properties  
of objects.

3 01:00:51:24 01:00:54:19 And to do that,  
we have set procedures

4 01:00:54:21 01:00:56:20 that enable us to measure.

5 01:00:56:22 01:00:58:12 Oh.

6 01:00:58:14 01:01:00:26 Measuring helps you  
to understand

7 01:01:00:28 01:01:03:08 how things relate to each other.

8 01:01:03:10 01:01:07:06 Our volume of a sphere  
actually has a formula

9 01:01:07:08 01:01:09:16 of  $\frac{4}{3} \pi r^3$ .

10 01:01:09:18 01:01:13:03 This course really made me think  
about how I approach measurement

11 01:01:13:05 01:01:16:05 and how I can use measurement  
every day in the classroom.

12 01:01:21:14 01:01:23:13 I think there's  
ten decimeters

13 01:01:23:15 01:01:25:01 in a meter.

14 01:01:25:03 01:01:26:18 Is that how it works?

15 01:01:26:20 01:01:28:13 MAN:  
I actually  
don't know.

16 01:01:28:15 01:01:30:13 I think it's a meter.

17 01:01:30:15 01:01:33:01 Ten decimeters...  
I hope I'm right.

18 01:01:33:03 01:01:34:17 NARRATOR:  
For many Americans,

19 01:01:34:19 01:01:38:14 the metric system is still  
an unfamiliar way to measure.

20 01:01:38:16 01:01:41:00 In this session, the class  
will examine the metric system

21 01:01:41:02 01:01:44:05 and begin to make sense of its  
units and their relationships

22 01:01:44:07 01:01:47:12 when measuring length,  
volume and mass.

23 01:01:47:14 01:01:49:09 A little history for you.

24 01:01:49:11 01:01:53:12 The metric system was  
pretty much established

25 01:01:53:14 01:01:56:02 in the late 1700s in France

26 01:01:56:04 01:01:57:27 right around  
the French Revolution,

27 01:01:57:29 01:02:03:21 and the reason was, they wanted  
to standardize units for trade.

28 01:02:03:23 01:02:08:24 As with any measurement system,  
we have to establish a unit,

29 01:02:08:26 01:02:10:13 and they started with a meter

30 01:02:10:15 01:02:12:28 and decided that the distance--

31 01:02:13:00 01:02:15:26 or the length, excuse me--  
of a meter

32 01:02:15:28 01:02:18:07 was going to be  
one-tenth... ten-millionth

33 01:02:18:09 01:02:22:05 of the distance between  
the equator and the North Pole.

34 01:02:22:07 01:02:23:17 All right?

35 01:02:23:19 01:02:25:27 Now, what's interesting  
about the metric system is

36 01:02:25:29 01:02:29:10 that we use one unit

37 01:02:29:12 01:02:33:07 as the main unit  
for each type of measurement.

38 01:02:33:09 01:02:36:12 So in measuring length,  
we have the meter,

39 01:02:36:14 01:02:40:26 and then when we want to use  
larger or smaller units,

40 01:02:40:28 01:02:44:06 we take the meter and either  
multiply it by powers of ten

41 01:02:44:08 01:02:47:02 or divide it by powers of ten.

42 01:02:47:04 01:02:50:08 Now, this makes the metric  
system very straightforward

43 01:02:50:10 01:02:51:23 and easy to use.

44 01:02:51:25 01:02:58:17 And so it was in 1960 that  
the metric system was revisited

45 01:02:58:19 01:03:01:04 and a system  
that was based on it

46 01:03:01:06 01:03:05:12 that is pretty much identical,  
but actually is different,

47 01:03:05:14 01:03:07:29 was the International  
System of Units.

48 01:03:08:01 01:03:11:07 And that is often  
known as the SI system,

49 01:03:11:09 01:03:16:27 and you may see it and hear  
about in science and math books.

50 01:03:16:29 01:03:20:25 Now, the difference between  
SI and the metric system

51 01:03:20:27 01:03:22:16 is negligible,

52 01:03:22:18 01:03:25:05 though, for scientists,  
there are some differences

53 01:03:25:07 01:03:26:21 that are important to them.

54 01:03:26:23 01:03:29:23 We're going to basically refer  
to them as the same thing.

55 01:03:29:25 01:03:31:29 So what I would like you to do

56 01:03:32:01 01:03:34:17 with your partner  
right this morning

57 01:03:34:19 01:03:36:10 is take a minute and think about

58 01:03:36:12 01:03:38:24 well, what units do I know  
in the metric system

59 01:03:38:26 01:03:40:14 and what relationships--

60 01:03:40:16 01:03:43:18 because those are the two things  
that form a measuring system--

61 01:03:43:20 01:03:45:13 am I aware of?

62 01:03:45:15 01:03:50:14 If you said kilometer,  
you can go to meter,

63 01:03:50:16 01:03:56:00 you can go to decimeter,  
you can go to centimeter,

64 01:03:56:02 01:03:59:19 and you can  
go to millimeter

65 01:03:59:21 01:04:02:21 without necessarily  
changing anything.

66 01:04:02:23 01:04:04:14 You either had  
to multiply by ten,

67 01:04:04:16 01:04:11:11 by 100, 1,000,  
one million and so on,

68 01:04:11:13 01:04:14:18 depending on the prefix  
that the unit has

69 01:04:14:20 01:04:17:08 and what you're  
converting it to.

70 01:04:17:10 01:04:18:25 That's how easy it is.

71 01:04:18:27 01:04:20:07 So did anyone come up  
72 01:04:20:09 01:04:22:15 with some interesting facts  
about the metric system

73 01:04:22:17 01:04:24:25 they'd like to share with us?

74 01:04:24:27 01:04:26:24 Well, David and I talked  
a lot about metric.

75 01:04:26:26 01:04:29:18 Luckily, he teaches it  
to his eighth-graders.

76 01:04:29:20 01:04:33:08 And we talked about meters  
and kilometers

77 01:04:33:10 01:04:35:15 and millimeters  
and centimeters

78 01:04:35:17 01:04:38:04 and how a kilometer  
is really

79 01:04:38:06 01:04:40:05 a thousand  
times a meter,

80 01:04:40:07 01:04:45:06 and a millimeter is  
a thousandth times  
a meter

81 01:04:45:08 01:04:48:17 and that a centimeter is  
a hundredth times a meter

82 01:04:48:19 01:04:51:07 and that we would  
use meters

83 01:04:51:09 01:04:52:15 to measure length.

84 01:04:52:17 01:04:54:21 CHAPIN:  
Okay, so these are  
all length measures.

85 01:04:54:23 01:04:55:21 All right.

86 01:04:55:23 01:04:57:18 And then we talked  
about liters

87 01:04:57:20 01:04:59:26 if we were measuring,  
say, water here

88 01:04:59:28 01:05:01:22 for volume  
and milliliters.

89 01:05:01:24 01:05:05:09 And then we talked about  
grams with kilograms

90 01:05:05:11 01:05:07:15 to measure weight.

91 01:05:07:17 01:05:10:29 For example, a person,  
you'd measure in kilograms,

92 01:05:11:01 01:05:13:07 and milligrams,  
that you would measure

93 01:05:13:09 01:05:16:21 maybe medicine  
or something small.

94 01:05:16:23 01:05:18:10 Grams and mil...

95 01:05:20:05 01:05:21:10 Milligrams.

96 01:05:21:12 01:05:22:15 All right.

97 01:05:22:17 01:05:23:27 Thank you.

98 01:05:23:29 01:05:29:00 So we've got some relationships  
here with length,

99 01:05:29:02 01:05:35:10 with volume and capacity  
and with weight or mass.

100 01:05:35:12 01:05:38:12 I think what makes this easier--  
the metric system--

101 01:05:38:14 01:05:43:14 it's that they are...  
the meter, and it's the center.

102 01:05:43:16 01:05:47:14 And then you have the multiples  
and submultiples of...

103 01:05:47:16 01:05:53:02 which are based in decimals,  
base ten.

104 01:05:53:04 01:05:55:07 CHAPIN:  
Right.

105 01:05:55:09 01:05:57:12 When Dave and I first started  
talking about this,

106 01:05:57:14 01:06:00:05 neither one of us were very  
comfortable with the topic,

107 01:06:00:07 01:06:03:22 so we did start  
with our basic meter.

108 01:06:03:24 01:06:08:07 And we made a visual of  
the meter being in our center

109 01:06:08:09 01:06:10:19 and then we took it  
down to the small side.

110 01:06:10:21 01:06:13:28 We went to deci,  
centi and milli.

111 01:06:14:00 01:06:16:26 And on the other side,  
on the larger side,

112 01:06:16:28 01:06:19:07 we did deca, hecto and kilo,

113 01:06:19:09 01:06:21:24 so we could visualize  
the center

114 01:06:21:26 01:06:23:11 and then  
to small

115 01:06:23:13 01:06:25:12 and then  
to the large.

116 01:06:25:14 01:06:26:26 And then we made  
the connection.

117 01:06:26:28 01:06:28:07 We said, if meter is length,

118 01:06:28:09 01:06:32:24 then the same ideas would apply  
to liters for volume

119 01:06:32:26 01:06:35:28 and grams for mass.

120 01:06:36:00 01:06:38:28 And you can just apply  
those different prefixes

121 01:06:39:00 01:06:40:15 to each one of  
those basic units.

122 01:06:40:17 01:06:42:19 And we thought that  
helped us a little bit

123 01:06:42:21 01:06:43:26 to think of it that way.

124 01:06:43:28 01:06:45:08 CHAPIN:  
Great.

125 01:06:45:10 01:06:48:11 One the difficulties for us  
is that many of us

126 01:06:48:13 01:06:50:16 are not totally familiar  
with these prefixes.

127 01:06:50:18 01:06:52:14 So we say, okay,  
I understand a meter.

128 01:06:52:16 01:06:53:28 I kind of know that,

129 01:06:54:00 01:06:56:00 and I understand

130 01:06:56:02 about centimeters and...  
 01:06:59:16 But what happens when we get  
 bigger or smaller quantities  
 131 01:06:59:18 01:07:01:27 in terms of these powers of ten?  
 132 01:07:01:29 01:07:04:16 Take a minute and  
 look at your chart  
 133 01:07:04:18 01:07:08:15 and think about what patterns  
 do you notice.  
 134 01:07:08:17 01:07:11:07 WOMAN:  
 As you move up  
 from the base unit,  
 135 01:07:11:09 01:07:15:12 you're increasing by tens  
 136 01:07:15:14 01:07:17:21 to going increasingly  
 larger numbers,  
 137 01:07:17:23 01:07:18:29 and as you're moving down,  
 138 01:07:19:01 01:07:21:23 you're going to increasingly  
 smaller numbers  
 139 01:07:21:25 01:07:23:24 in the reverse pattern.  
 140 01:07:23:26 01:07:25:07 CHAPIN:  
 Exactly.  
 141 01:07:25:09 01:07:27:15 And notice that we're  
 getting increasingly larger.  
 142 01:07:27:17 01:07:30:20 That's represented  
 by using exponents.  
 143 01:07:30:22 01:07:33:06 And so as we get larger,  
 we're using ten to the first,  
 144 01:07:33:08 01:07:34:29 ten to the second,  
 ten to the third.  
 145 01:07:35:01 01:07:39:01 Then we go up to ten to the  
 sixth, ten to the ninth, 12th,  
 146 01:07:39:03 01:07:41:25 ten to the 15th,  
 ten to the 18th.  
 147 01:07:41:27 01:07:44:15 Notice we're going  
 in groups of a thousand,  
 148 01:07:44:17 01:07:46:15 ten to the third power.  
 149 01:07:46:17 01:07:50:21 We're making  
 these big increases.  
 150 01:07:50:23 01:07:53:24 Likewise, when we represent  
 very small numbers,  
 151 01:07:53:26 01:07:56:08 we use a negative exponent,  
 152 01:07:56:10 01:08:00:27 so that when we are saying here  
 ten to the negative one,  
 153 01:08:00:29 01:08:03:17 that represents one-tenth.  
 154 01:08:03:19 01:08:05:00 Since you do go up by...  
 155 01:08:05:02 01:08:08:19 Well, you go zero, one, two,  
 three, six, nine, 12.  
 156 01:08:08:21 01:08:12:04 There are things in between  
 that have names to them also,  
 157 01:08:12:06 01:08:14:16 don't they?  
 158 01:08:14:18 01:08:15:16 Their values, yes.  
 159 01:08:15:18 01:08:17:09 I mean, we can have a measure  
 160 01:08:17:11 01:08:20:00 that is equivalent  
 to ten to the fifth power,  
 161 01:08:20:02 01:08:23:11 however, it doesn't have  
 a specific prefix  
 162 01:08:23:13 01:08:26:12 that goes

with it.

163 01:08:26:14 01:08:29:21 There's one other point I wanted  
to make, and that is

164 01:08:29:23 01:08:32:02 that when we are working  
with powers of ten

165 01:08:32:04 01:08:33:22 in the metric system,  
166 01:08:33:24 01:08:38:09 it allows us to just use  
decimal notation.

167 01:08:38:11 01:08:43:19 And thus, you will not see  
3½ centimeters,  
168 01:08:43:21 01:08:47:17 it would be recorded  
as "3.5 centimeters."

169 01:08:47:19 01:08:52:13 And this ability of powers of  
ten allows us to go up and down,  
170 01:08:52:15 01:08:58:15 in terms of finding  
equivalencies, quite easily,  
171 01:08:58:17 01:08:59:27 and it also allows us  
172 01:08:59:29 01:09:02:21 not to have to work  
with very messy fractions.

173 01:09:02:23 01:09:04:18 CHAPIN:  
There are a number  
of important ideas  
174 01:09:04:20 01:09:06:26 that I was hoping participants  
would grapple with.

175 01:09:06:28 01:09:09:09 One is that there is one unit  
176 01:09:09:11 01:09:12:08 associated with  
each type of measure,  
177 01:09:12:10 01:09:15:22 and that unit can be partitioned  
into smaller units  
178 01:09:15:24 01:09:17:13 by using powers of ten,  
179 01:09:17:15 01:09:20:20 and it can also be extended  
into larger units  
180 01:09:20:22 01:09:23:18 by multiplying by powers of ten.  
181 01:09:23:20 01:09:25:04 The second aspect was  
182 01:09:25:06 01:09:27:16 that prefixes used  
in the metric system  
183 01:09:27:18 01:09:32:06 enable us to move forward  
or up to larger units  
184 01:09:32:08 01:09:36:06 and back to smaller units  
with great ease and flexibility.

185 01:09:36:08 01:09:39:02 NARRATOR:  
This means by simply  
moving a decimal point,  
186 01:09:39:04 01:09:41:27 measurement may be represented  
in different ways.

187 01:09:41:29 01:09:46:01 For example, ten millimeters may  
be expressed as one centimeter,  
188 01:09:46:03 01:09:48:13 100 centimeters as one meter  
189 01:09:48:15 01:09:51:19 and 1,000 meters  
as one kilometer.

190 01:09:51:21 01:09:54:04 We are next going to move  
to an opportunity  
191 01:09:54:06 01:09:56:15 for you to establish  
some benchmarks  
192 01:09:56:17 01:09:59:29 for linear measurement.  
193 01:10:00:01 01:10:01:29 In your packet,

194 01:10:02:01 01:10:07:06 you will see some examples  
of some people there.

195 01:10:07:08 01:10:11:11 And what I would like you to do  
is take some body measurements

196 01:10:11:13 01:10:18:01 to help you establish some  
referent values for yourself.

197 01:10:18:03 01:10:21:22 I happen to know that the width  
of my pinkie is a centimeter,

198 01:10:21:24 01:10:23:10 and that is very handy

199 01:10:23:12 01:10:28:27 when I'm trying to make some  
estimates of some short lengths.

200 01:10:28:29 01:10:30:04 Shall I do your hand?

201 01:10:30:06 01:10:31:11 Sure.

202 01:10:31:13 01:10:32:20 Okay.

203 01:10:32:22 01:10:35:17 So we'll go from here...  
to here.

204 01:10:35:19 01:10:36:27 Hey, how about that?

205 01:10:36:29 01:10:39:20 A decimeter.

206 01:10:41:13 01:10:42:27 I'll have you do mine.

207 01:10:42:29 01:10:44:17 I don't know,  
I have big hands.

208 01:10:44:19 01:10:46:16 Mine are pudgy, so...

209 01:10:46:18 01:10:47:25 Look at that.

210 01:10:47:27 01:10:49:13 Wow! That's cool.

211 01:10:49:15 01:10:52:16 CHAPIN:  
If you don't have  
a benchmark in measurement,

212 01:10:52:18 01:10:55:25 you then, in many cases,  
cannot think carefully

213 01:10:55:27 01:10:58:29 about how reasonable  
is my measure.

214 01:10:59:01 01:11:00:14 In that benchmark activity,

215 01:11:00:16 01:11:02:28 the first thing that  
participants were asked to do

216 01:11:03:00 01:11:05:23 was to measure different parts  
of their body,

217 01:11:05:25 01:11:07:28 for example, the distance  
from their shoulder

218 01:11:08:00 01:11:10:10 out to the tips  
of their fingers.

219 01:11:10:12 01:11:11:14 And for many people,

220 01:11:11:16 01:11:13:26 that distance is  
approximately one meter.

221 01:11:15:23 01:11:18:17 And two of me, okay?

222 01:11:21:02 01:11:23:23 Now it's three  
of you?

223 01:11:23:25 01:11:25:23 NARRATOR:  
Using these personal benchmarks,

224 01:11:25:25 01:11:28:06 participants were asked  
to measure the classroom,

225 01:11:28:08 01:11:30:07 checking their results  
afterwards

226 01:11:30:09 01:11:33:00 with a device known as  
a "trundle wheel."

227 01:11:33:02 01:11:35:10 CHAPIN:  
And the trundle wheel

228 01:11:35:12 just moves along,  
 01:11:38:21 and every time you have  
 progressed one meter,  
 229 01:11:38:23 01:11:41:03 it will click.  
 230 01:11:41:05 01:11:43:06 So participants then  
 could gather the data  
 231 01:11:43:08 01:11:45:15 and then compare  
 their measurement  
 232 01:11:45:17 01:11:50:18 from using body benchmarks to  
 using the actual trundle wheel.  
 233 01:11:53:20 01:11:55:03 ( *wheel clicks* )  
 234 01:11:55:05 01:11:56:20 Eight...  
 235 01:11:56:22 01:11:58:21 And now we have to...  
 236 01:11:58:23 01:12:00:24 And 50 centimeters.  
 237 01:12:00:26 01:12:02:18 So 850?  
 238 01:12:02:20 01:12:04:23 So eight and a half.  
 239 01:12:04:25 01:12:07:27 See, we had 912 by going  
 finger to finger,  
 240 01:12:07:29 01:12:09:18 so that's not too bad.  
 241 01:12:09:20 01:12:11:12 Not too bad.  
 242 01:12:14:18 01:12:17:18 In our next activity,  
 we are going to investigate  
 243 01:12:17:20 01:12:23:20 how we measure volume, or  
 capacity, in the metric system.  
 244 01:12:23:22 01:12:25:19 Volume is a measure of space,  
 245 01:12:25:21 01:12:29:09 whether it is solid volume  
 or liquid volume.  
 246 01:12:29:11 01:12:35:10 And the unit that is used in the  
 SI system is the cubic meter.  
 247 01:12:35:12 01:12:38:01 Now, to get a handle  
 on the size of a cubic meter,  
 248 01:12:38:03 01:12:41:18 I'm going to ask Lombie  
 to come on up here  
 249 01:12:41:20 01:12:44:08 and you may need to  
 stand up in the back  
 250 01:12:44:10 01:12:47:10 because we've got  
 the beginnings of  
 a cubic meter  
 251 01:12:47:12 01:12:48:13 here on the floor.  
 252 01:12:48:15 01:12:50:00 Now, Lombie, would you  
 come over here  
 253 01:12:50:02 01:12:55:23 and hold that meter stick  
 right on the base  
 254 01:12:55:25 01:12:57:26 just like this?  
 255 01:12:57:28 01:12:59:03 Like that, okay.  
 256 01:12:59:05 01:13:01:22 And then you're going  
 to take another one,  
 257 01:13:01:24 01:13:05:20 and you're going to hold it...  
 258 01:13:05:22 01:13:08:11 maybe out like this  
 or hold it like that.  
 259 01:13:08:13 01:13:12:04 CHAPIN:  
 The standard unit for solid  
 volume is the cubic meter,  
 260 01:13:12:06 01:13:13:21 so we built a cubic meter  
 261 01:13:13:23 01:13:16:06 just to get a sense  
 of how large is that.



262 01:13:16:08 01:13:19:03 We then broke it down  
into smaller parts,

263 01:13:19:05 01:13:22:08 looked at cubic decimeters,  
cubic centimeters

264 01:13:22:10 01:13:26:05 and then related that to  
both liters and milliliters.

265 01:13:26:07 01:13:30:07 One of the very interesting  
aspects of the metric system is

266 01:13:30:09 01:13:34:10 that one liter is equivalent  
to one cubic decimeter.

267 01:13:34:12 01:13:36:21 Likewise, if we go even smaller,

268 01:13:36:23 01:13:40:19 one milliliter is equivalent  
to one cubic centimeter.

269 01:13:40:21 01:13:43:05 Anybody know what this unit is?

270 01:13:45:23 01:13:46:26 A cubic decimeter?

271 01:13:46:28 01:13:48:11 CHAPIN:  
Yeah, it's  
a cubic decimeter.

272 01:13:48:13 01:13:51:19 How long is each side  
of this cube?

273 01:13:51:21 01:13:53:00 A decimeter.

274 01:13:53:02 01:13:55:01 A decimeter-- which is ten  
centimeters, all right?

275 01:13:55:03 01:13:58:05 And how many cubic centimeters  
are in here?

276 01:13:58:07 01:14:00:17 Remember,  
those tiny little cubes

277 01:14:00:19 01:14:02:21 we were using the other day.

278 01:14:02:23 01:14:03:29 WOMAN:  
A hundred?

279 01:14:04:01 01:14:05:14 Let's see.

280 01:14:05:16 01:14:09:29 Ten this way, ten this way  
and ten height-- a thousand.

281 01:14:10:01 01:14:13:22 So we have a thousand  
cubic centimeters

282 01:14:13:24 01:14:16:15 are in this cubic decimeter.

283 01:14:16:17 01:14:19:03 Now, what's really interesting

284 01:14:19:05 01:14:22:06 is one of these  
is equal to a liter.

285 01:14:22:08 01:14:24:23 Again, because we haven't  
had the experience

286 01:14:24:25 01:14:27:13 with working  
with these measures,

287 01:14:27:15 01:14:29:10 we are going to work through

288 01:14:29:12 01:14:32:01 um, some of the activities  
in your packet

289 01:14:32:03 01:14:35:00 to explore, um,  
how much is a liter,

290 01:14:35:02 01:14:39:29 how much... how does that relate  
to, um, cubic centimeters.

291 01:14:40:01 01:14:43:09 And we have some bottles  
at your table,

292 01:14:43:11 01:14:46:15 um, and you have some beakers

293 01:14:46:17 01:14:48:26 that you'll be able to use  
for measuring.

294 01:14:48:28 01:14:50:22 We're going to ask ourselves,

295 01:14:50:24 01:14:52:24 well, if this  
is a liter bottle,

296 01:14:52:26 01:14:55:20 is there actually a liter  
of liquid in here?

297 01:14:55:22 01:14:56:28 All right?

298 01:14:57:00 01:14:59:11 Let's see if we can  
actually pull this off...

299 01:14:59:13 01:15:01:21 without spilling any.

300 01:15:01:23 01:15:06:08 (*students talking*)

301 01:15:08:05 01:15:09:18 WOMAN:  
Mmm... a little more?

302 01:15:09:20 01:15:10:22 Yep.

303 01:15:10:24 01:15:12:09 Um...

304 01:15:12:11 01:15:14:05 Are we there or we  
need a little bit more?

305 01:15:14:07 01:15:15:14 It's a tiny bit  
below the line.

306 01:15:15:16 01:15:16:25 Maybe just a drop  
or two more.

307 01:15:20:15 01:15:21:17 Yep.

308 01:15:21:19 01:15:22:17 That it?

309 01:15:22:19 01:15:23:17 That's it.

310 01:15:23:19 01:15:25:01 Okay, that's 500.

311 01:15:25:03 01:15:26:15 So we have to...

312 01:15:26:17 01:15:27:15 Dump it.

313 01:15:27:17 01:15:28:15 Dump this out.

314 01:15:28:17 01:15:29:15 All right.

315 01:15:29:17 01:15:30:26 Okay.

316 01:15:30:28 01:15:32:28 So we should hopefully  
have 500 milliliters more.

317 01:15:33:00 01:15:34:11 It's going to  
be a little bit off

318 01:15:34:13 01:15:35:26 because of the drops  
on the bottom.

319 01:15:35:28 01:15:37:01 Right.

320 01:15:42:08 01:15:44:23 Hmm, maybe we actually  
got some money here.

321 01:15:46:21 01:15:48:03 That's 500.

322 01:15:48:05 01:15:49:15 Oh, there's more water.

323 01:15:49:17 01:15:52:23 There's actually  
a little bit of water left.

324 01:15:52:25 01:15:54:16 So there's 500 and 500.

325 01:15:54:18 01:15:56:09 So that's interesting.

326 01:15:56:11 01:15:59:24 CHAPIN:  
Participants were involved  
with taking liter bottles

327 01:15:59:26 01:16:02:26 and estimating how much  
is actually in that bottle.

328 01:16:02:28 01:16:06:02 They were all surprised when  
they poured out the liquid

329 01:16:06:04 01:16:09:07 to find that it actually  
was greater than one liter.

330 01:16:09:09 01:16:11:18 That led us to think  
about practical issues

331 01:16:11:20 01:16:12:28 of, well, why is it

332 01:16:13:00 01:16:16:07 that when we are buying

333 01:16:16:09 01:16:18:15 a liter of some liquid,  
 they actually have  
 a little more?  
 334 01:16:18:17 01:16:20:03 It... it raises the question  
 335 01:16:20:05 01:16:23:08 of how accurate are machines  
 that are filling those bottles,  
 336 01:16:23:10 01:16:25:02 that there probably  
 is some error.  
 337 01:16:25:04 01:16:26:26 They didn't want  
 to err on the side  
 338 01:16:26:28 01:16:28:19 of not giving you  
 your full liter,  
 339 01:16:28:21 01:16:31:05 so they're going to err  
 a little bit on the side  
 340 01:16:31:07 01:16:33:23 of probably coming  
 to a little more than a liter.  
 341 01:16:37:29 01:16:40:20 In our final activity  
 for this session,  
 342 01:16:40:22 01:16:42:29 were going to look at weight,  
 or mass.  
 343 01:16:43:01 01:16:44:25 Now, one of the confusions  
 344 01:16:44:27 01:16:48:22 of why there's this difference  
 between weight and mass  
 345 01:16:48:24 01:16:51:10 is that in  
 the U.S. Customary System,  
 346 01:16:51:12 01:16:53:21 the units are pounds and ounces,  
 347 01:16:53:23 01:16:56:22 and these were developed  
 to measure weight,  
 348 01:16:56:24 01:17:00:05 which is the, um,  
 amount of gravitational force  
 349 01:17:00:07 01:17:01:26 being put on an object.  
 350 01:17:01:28 01:17:05:25 Your weight can change if you  
 are here in this classroom  
 351 01:17:05:27 01:17:07:10 or if you go to the moon  
 352 01:17:07:12 01:17:08:24 and ever so slightly  
 353 01:17:08:26 01:17:11:21 if, perhaps, you were on top  
 of a very high mountain.  
 354 01:17:11:23 01:17:13:09 Mass, on the other hand--  
 355 01:17:13:11 01:17:17:01 which is the units that are used  
 for the metric system--  
 356 01:17:17:03 01:17:20:23 remain the same and are used  
 with our balance scales.  
 357 01:17:20:25 01:17:22:24 And so it's one reason why  
 358 01:17:22:26 01:17:27:08 we are constantly talking  
 about mass in the metric system,  
 359 01:17:27:10 01:17:28:22 not weight.  
 360 01:17:28:24 01:17:30:02 All right?  
 361 01:17:30:04 01:17:33:28 Now, the unit that is used  
 for the SI system,  
 362 01:17:34:00 01:17:36:18 or the metric system,  
 is the kilogram,  
 363 01:17:36:20 01:17:38:00 and kilograms are used  
 364 01:17:38:02 01:17:40:17 to weigh things like tables,  
 books, ourselves.  
 365 01:17:40:19 01:17:43:15 Grams are used to weigh things  
 that are very small.

366 01:17:43:17 01:17:45:00 We can have milligrams.  
 367 01:17:45:02 01:17:49:25 If we have a thousand kilograms,  
 we have a megagram,  
 368 01:17:49:27 01:17:53:26 and that's, um,  
 often known as a metric ton.  
 369 01:17:53:28 01:17:56:25 That's a... a much bigger unit.  
 370 01:17:56:27 01:17:59:00 Now, we're going to explore  
 371 01:17:59:02 01:18:02:29 some different aspects  
 and relationships in mass.  
 372 01:18:03:01 01:18:06:04 And the first thing  
 we're going to do is  
 373 01:18:06:06 01:18:09:16 a way to get a sense  
 of how much is a gram.  
 374 01:18:09:18 01:18:14:12 I'm going to ask you  
 to use gram weights  
 375 01:18:14:14 01:18:18:23 and find something  
 that weighs just a few grams,  
 376 01:18:18:25 01:18:20:24 so you can get a sense  
 of that mass.  
 377 01:18:20:26 01:18:22:05 Want to use  
 the pencil?  
 378 01:18:22:07 01:18:24:04 We were talking about  
 a pen or pencil before.  
 379 01:18:24:06 01:18:25:04 Okay.  
 380 01:18:25:06 01:18:26:05 Um...  
 381 01:18:26:07 01:18:27:13 Is this zeroed?  
 382 01:18:27:15 01:18:29:26 It is, yeah, it's...  
 yeah, I balanced it.  
 383 01:18:29:28 01:18:31:01 Balanced, okay.  
 384 01:18:32:03 01:18:33:05 That's a five.  
 385 01:18:33:07 01:18:34:28 I don't think there's  
 any gram pieces.  
 386 01:18:35:00 01:18:35:29 MAN:  
 We don't have any?  
 387 01:18:36:01 01:18:36:29 No.  
 388 01:18:37:01 01:18:38:09 Do we have them  
 in our basket?  
 389 01:18:38:11 01:18:40:06 We have those little chips  
 that we used.  
 390 01:18:40:08 01:18:42:00 WOMAN:  
 Oh, we do--  
 five's the smallest.  
 391 01:18:42:02 01:18:43:17 We have the little ones  
 in here.  
 392 01:18:44:23 01:18:46:09 Six...  
 393 01:18:46:11 01:18:48:03 seven... oop.  
 394 01:18:48:05 01:18:49:04 No.  
 395 01:18:49:06 01:18:50:18 You think one more?  
 396 01:18:50:20 01:18:53:00 Okay, try one more  
 and see if it goes  
 beyond the line.  
 397 01:18:53:02 01:18:54:05 Yeah.  
 398 01:18:54:07 01:18:55:15 WOMAN:  
 It's in between  
 the two.  
 399 01:18:55:17 01:18:57:04 WOMAN:

Which is what we want, right?

400 01:18:57:06 01:18:58:19 So it's between eight and nine?

401 01:18:58:21 01:19:00:29 CHAPIN:  
In this session, there were a number of things

402 01:19:01:01 01:19:03:11 that participants were able to really engage with.

403 01:19:03:13 01:19:04:20 One was understanding

404 01:19:04:22 01:19:07:02 the relationships in the metric system,

405 01:19:07:04 01:19:09:16 how the metric system was constructed.

406 01:19:09:18 01:19:12:17 Hopefully, also, participants had the opportunity

407 01:19:12:19 01:19:14:21 to start to establish for themselves

408 01:19:14:23 01:19:16:18 their own personal benchmarks--

409 01:19:16:20 01:19:18:10 What's the mass of a gram?

410 01:19:18:12 01:19:19:29 What's the mass of a kilogram?

411 01:19:20:01 01:19:20:29 MAN:  
This company

412 01:19:21:01 01:19:22:14 fills it right to the top there.

413 01:19:22:16 01:19:23:25 (*speaking over each other*)

414 01:19:23:27 01:19:25:03 Wow.

415 01:19:25:05 01:19:26:24 MAN:  
Oh, my goodness, almost to the drop.

416 01:19:26:26 01:19:28:07 NARRATOR:  
In a final activity,

417 01:19:28:09 01:19:30:19 participants measure the mass of a liter of water

418 01:19:30:21 01:19:33:07 and discover that it is equal to one kilogram.

419 01:19:33:09 01:19:35:03 Do you have a hundred uh...

420 01:19:35:05 01:19:37:13 I think that's going to be way over a hundred.

421 01:19:37:15 01:19:39:05 I think that's going to be five...

422 01:19:39:07 01:19:40:20 MAN:  
I think about a thousand.

423 01:19:40:22 01:19:43:17 WOMAN:  
A thousand?

424 01:19:43:19 01:19:44:17 That's a thousand.

425 01:19:44:19 01:19:45:21 WOMAN:  
Oh, it's more.

426 01:19:45:23 01:19:46:21 Do you have the 500?

427 01:19:46:23 01:19:47:21 MAN:  
Oh, my gosh.

428 01:19:47:23 01:19:48:28 LOMBIE:  
I... I know we have...

429 01:19:49:00 01:19:50:01 MAN:

Yeah, 50,  
here we go.

430 01:19:50:03 01:19:52:00 No... 100.  
431 01:19:52:02 01:19:53:09 Hundred.  
432 01:19:53:11 01:19:54:10 How about  
just 200?  
433 01:19:54:12 01:19:55:15 Hundred's too much.  
434 01:19:55:17 01:19:57:18 Between... between 50  
and a hundred.  
435 01:19:57:20 01:19:58:26 And there is a 20 there.  
436 01:19:58:28 01:19:59:28 15, 20... there's 70.  
437 01:20:00:00 01:20:01:05 That's a little  
too much.  
438 01:20:01:07 01:20:02:21 WOMAN:  
Can we use  
some of these?  
439 01:20:02:23 01:20:05:20 MAN:  
A thousand, a 15,  
a ten, 60?  
440 01:20:05:22 01:20:06:20 WOMAN:  
Ooh!  
441 01:20:08:06 01:20:09:11 We could use these maybe.  
442 01:20:09:13 01:20:10:18 Yeah.  
443 01:20:10:20 01:20:12:09 To get down to the,  
uh, single digits.  
444 01:20:12:11 01:20:13:09 That's right.  
445 01:20:13:11 01:20:15:14 MAN:  
A 1,060.  
446 01:20:15:16 01:20:17:14 WOMAN:  
1,060 grams.  
447 01:20:17:16 01:20:18:19 MAN:  
Grams.  
448 01:20:18:21 01:20:19:26 LOMBIE:  
1,061.  
449 01:20:21:13 01:20:22:26 WOMAN:  
Just one more, right?  
450 01:20:22:28 01:20:25:03 1,065?  
451 01:20:25:05 01:20:26:24 LOMBIE:  
1,065, mm-hmm.  
452 01:20:26:26 01:20:28:02 What have you guys  
figured out?  
453 01:20:28:04 01:20:29:10 Oh... it's heavy.  
454 01:20:29:12 01:20:30:10 Yeah?  
455 01:20:30:12 01:20:31:10 Relatively.  
456 01:20:31:12 01:20:32:10 Okay.  
457 01:20:32:12 01:20:33:10 Wait, so,  
a thousand...  
458 01:20:33:12 01:20:34:20 65.  
459 01:20:34:22 01:20:37:20 A thousand milliliters  
equals approximately...  
460 01:20:37:22 01:20:39:10 a thousand grams,  
but not quite.  
461 01:20:39:12 01:20:41:06 But wait-- with  
the bottle weight...  
462 01:20:41:08 01:20:42:23 With the bottle...  
463 01:20:42:25 01:20:45:08 MAN:

We have to subtract  
the bottle weight.

464 01:20:45:10 01:20:47:00 CHAPIN:  
The concepts that are involved

465 01:20:47:02 01:20:48:24 in this session today  
are very important

466 01:20:48:26 01:20:51:23 because we also want to become  
part of the world community.

467 01:20:51:25 01:20:54:18 The United States is  
the only industrial nation

468 01:20:54:20 01:20:57:00 that has not  
completely gone to metrics,

469 01:20:57:02 01:21:00:11 and as a result,  
we are at a disadvantage

470 01:21:00:13 01:21:02:14 in some trade situations.

471 01:21:02:16 01:21:04:05 However, in order to compete,

472 01:21:04:07 01:21:06:21 we're moving more and more  
towards metrics,

473 01:21:06:23 01:21:08:08 and so we really all need

474 01:21:08:10 01:21:10:29 to become a lot more familiar  
with this system

475 01:21:11:01 01:21:13:05 because it...  
it really is inevitable

476 01:21:13:07 01:21:15:28 that that is going  
to be a part of our future.

477 01:21:21:22 01:21:24:00 ( *panting* )

478 01:21:24:02 01:21:26:09 NARRATOR:  
Levi, a purebred Boxer,

479 01:21:26:11 01:21:29:05 is making his way  
to Angell Memorial Hospital,

480 01:21:29:07 01:21:31:13 a renowned veterinary facility

481 01:21:31:15 01:21:37:02 run by the Massachusetts Society  
for the Prevention of Cruelty  
to Animals.

482 01:21:37:04 01:21:40:19 Inside, pets of all shapes  
and sizes anxiously await care,

483 01:21:40:21 01:21:43:25 from a simple checkup  
to lifesaving procedures.

484 01:21:43:27 01:21:47:08 Good treatment like this often  
begins with a hop on a scale.

485 01:21:47:10 01:21:50:18 But don't be surprised when  
the results are in kilograms,

486 01:21:50:20 01:21:52:25 not pounds.

487 01:21:52:27 01:21:55:09 WOMAN:  
Veterinary medicine  
uses the metric system

488 01:21:55:11 01:21:56:25 for a lot of reasons.

489 01:21:56:27 01:21:58:20 I think the biggest reason is

490 01:21:58:22 01:22:02:01 that it's the internationally  
accepted system,

491 01:22:02:03 01:22:05:28 and this way,  
we can use the same data,

492 01:22:06:00 01:22:08:11 use the same drug, doses

493 01:22:08:13 01:22:14:02 as anyone else in the world  
who does veterinary medicine.

494 01:22:14:04 01:22:18:13 NARRATOR:

Dr. Moses is on the Emergency and Critical Care staff at Angell Memorial.

495 01:22:18:15 01:22:19:23 at Angell Memorial.  
496 01:22:19:25 01:22:21:14 For her, the metric system  
497 01:22:21:16 01:22:24:19 helps provide better treatment for her patients.

498 01:22:24:21 01:22:26:14 MOSES:  
The metric system  
499 01:22:26:16 01:22:29:20 really does help us be precise in measurements.

500 01:22:29:22 01:22:33:16 We have machines sitting on the cages of the animals,  
501 01:22:33:18 01:22:36:14 that have fluid bags hooked up to them,  
502 01:22:36:16 01:22:38:26 and we dial into those machines  
503 01:22:38:28 01:22:41:21 how many milliliters of fluid per hour  
504 01:22:41:23 01:22:43:10 we want to give a patient.  
505 01:22:43:12 01:22:46:22 And it's extremely important that those be very precise  
506 01:22:46:24 01:22:50:00 because there are often drugs mixed into those fluids,  
507 01:22:50:02 01:22:52:19 or we may even be giving blood transfusions  
508 01:22:52:21 01:22:54:09 or intravenous nutrition,  
509 01:22:54:11 01:22:58:06 all of which, of course, have to be done very accurately.

510 01:23:00:07 01:23:02:25 NARRATOR:  
While examining one of her four-legged patients,  
511 01:23:02:27 01:23:07:02 Dr. Moses often uses a number of diagnostic tools  
512 01:23:07:04 01:23:08:25 that operate in the metric system.

513 01:23:08:27 01:23:12:27 MOSES:  
Blood pressure monitoring is based on the metric system  
514 01:23:12:29 01:23:15:12 because what we actually are measuring  
515 01:23:15:14 01:23:17:00 is the... the pulse pressure,  
516 01:23:17:02 01:23:18:13 and the units  
517 01:23:18:15 01:23:21:07 that the pulse pressure is universally measured in  
518 01:23:21:09 01:23:24:25 is millimeters of mercury.  
519 01:23:24:27 01:23:27:12 Other measuring tools that we use  
520 01:23:27:14 01:23:32:06 are things like an EKG monitor, where we're actually measuring  
521 01:23:32:08 01:23:35:03 the electrical activity of the heart.  
522 01:23:35:05 01:23:38:09 That's measured in millivolts per second.

523 01:23:38:11 01:23:40:14 NARRATOR:  
One of the primary reasons  
524 01:23:40:16 01:23:43:23 these medical devices use the same form of measurement



525 01:23:43:25 01:23:46:26 is that they all need to  
interact with each other.

526 01:23:46:28 01:23:48:08 MOSES:  
For example,

527 01:23:48:10 01:23:51:11 if we have a patient  
who is on a ventilator,

528 01:23:51:13 01:23:54:05 we have that patient  
hooked up to things

529 01:23:54:07 01:23:56:17 that monitor  
their blood pressure,

530 01:23:56:19 01:23:59:16 things that monitor  
their respiration rate

531 01:23:59:18 01:24:02:17 and give that information back  
to the ventilator

532 01:24:02:19 01:24:05:07 so that the ventilator  
can make adjustments

533 01:24:05:09 01:24:07:15 in how much the patient  
is breathing.

534 01:24:07:17 01:24:09:05 Good girl.

535 01:24:09:07 01:24:11:10 NARRATOR:  
At the hospital pharmacy,

536 01:24:11:12 01:24:13:27 the metric system  
also plays a prominent role.

537 01:24:13:29 01:24:17:19 MOSES:  
When we have to take drugs  
that are meant to be given

538 01:24:17:21 01:24:23:01 to people who are as big  
as an average human man

539 01:24:23:03 01:24:25:21 and then scaling it down  
to a parakeet size,

540 01:24:25:23 01:24:28:10 we have to do special  
compounding.

541 01:24:28:12 01:24:32:06 And the way that we can  
do precision compounding

542 01:24:32:08 01:24:36:00 is we weigh things out  
in milligram measurements

543 01:24:36:02 01:24:40:01 and sometimes smaller  
than milligram measurements.

544 01:24:40:03 01:24:43:21 NARRATOR:  
Using the metric system  
has become second nature

545 01:24:43:23 01:24:46:11 to the staff  
at Angell Memorial Hospital.

546 01:24:46:13 01:24:49:15 For Dr. Moses though,  
this was not always the case.

547 01:24:49:17 01:24:53:22 MOSES:  
It wasn't something that I used  
in my everyday life very often

548 01:24:53:24 01:24:56:10 until I really got  
into veterinary school

549 01:24:56:12 01:24:59:07 where all of a sudden  
that was the only system,

550 01:24:59:09 01:25:02:11 and it really was  
a very easy transition

551 01:25:02:13 01:25:03:28 because once you see

552 01:25:04:00 01:25:07:16 that it is this simplified

system based on ten,  
553 01:25:07:18 01:25:09:25 it's not hard to convert over.  
554 01:25:09:27 01:25:13:29 I think what I find hardest now  
is that in the rest of my life,  
555 01:25:14:01 01:25:15:29 nothing's in the metric system,  
556 01:25:16:01 01:25:19:04 and I have to go back and forth  
between the two.  
557 01:25:19:06 01:25:22:29 I'm not sure whether or not the  
United States will ever convert.  
558 01:25:23:01 01:25:24:22 I sure hope they do.  
559 01:25:24:24 01:25:26:26 It would make my life  
a lot simpler.  
560 01:25:26:28 01:25:29:14 For all of us in science fields,  
561 01:25:29:16 01:25:32:12 I know we'd all be glad  
to have only one system.  
562 01:25:32:14 01:25:35:01 ( *dogs barking* )  
563 01:25:36:27 01:25:43:07 Captioned by  
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