Start by watching the Youtube video, Last Week Tonight with John Oliver on Scientific Studies (it probably contains explicit language - you are warned).

Read:

- The activity on finding "reliable" sources showed one obstacle to understanding nature: <u>we have to be comfortable with less than perfect certainty</u>. That's fine, because we can get pretty close.
- The activity on the structure of an argument and logical fallacies showed another obstacle to understanding nature: all of us can make arguments that are wrong in many ways. In other words, <u>we are all biased thinkers</u>.
- Pure <u>chance</u> can also be an obstacle to knowing something. Historical sciences like paleontology, and archaeology are interested in the past and many events in the past cannot be reproduced. While they can sometimes figure out what probably happened with multiple lines of evidence, other times the evidence isn't there, just by chance.
- Physics is concerned with the way nature seems to consistently and reliably behave: past, present, and future (probably). So, we can perform experiments and reproduce events many times to be more confident in the results. This is how to do it.

Tip 1: Remember and Use the Logic Involved in Testing a Claim

1. Answer individually: You have a ramp of a certain length and angle, along with three spheres made of different types of metal but all coated with the same painted surface. As shown in the figure below, ball 1 has a mass of 10kg and a diameter of 10cm, ball 2 has a mass of 5kg and a diameter of 10cm, and ball 3 has a mass of 5kg and a diameter of 5cm.

Ball 1
m=10kg
10cm

Ball 2
m=5kg
10cm

Ball 3
m=5kg
5cm
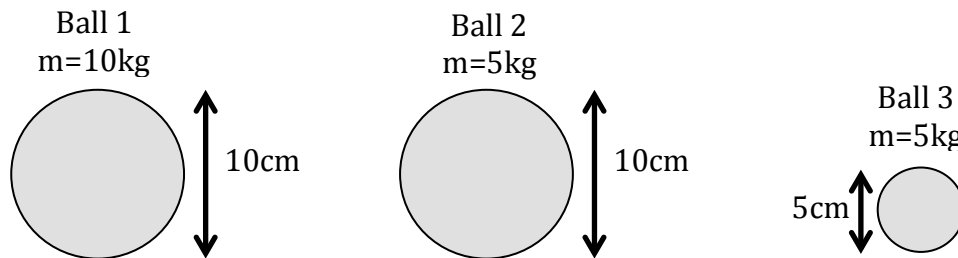
I <u>claim</u> that the size (diameter) of the ball affects the ball's speed at the bottom of the ramp.

<u>You want to test the claim I am making, by testing the effect of size on the ball's speed</u> at the bottom of the ramp. You start each ball from rest and measuring their final speed. You assume (reasonably) that the type of metal does not affect your result, only the mass or size. Which balls do you need to compare to perform this test?

    a) 1 and 2   b) 1 and 3   c) 2 and 3   d) all 3 needed   e) test cannot be done as stated

In groups:

2. For the previous question, you are trying to test the effect of size on the ball's final speed.
    a. What property of the balls do you want to vary between the different balls?
    b. What outcome are you measuring?
    c. What thing(s) are you trying to keep the same (constant)?
3. Come up with a careful statement or two supporting why your answers for the previous question test the effect of size on the ball's final speed.

4. Is it possible that something you are trying to keep constant (the same) from the last test you are doing varies just a tiny bit between trials (each roll of a ball we'll call a "trial")? If so, how do you (or did you) have to tweak your answer for the last question to make it correct? Make that modification, if needed.

5. What can you do to be more confident in your results of your test?

WRITE YOUR ANSWERS FOR 2-5 ON A WHITEBOARD AND PREPARE TO SHARE WITH THE CLASS

Individually:

6. Sometimes nobody makes a claim, explicitly. You just want to see what happens. Either way, you can IMAGINE somebody is making a particular claim, like I made before, and you want to see if they're right.

   Using the same equipment as before, now, you want to test the effect of mass on the ball's speed at the bottom of the ramp. You start each ball from rest and measuring their final speed. You assume (reasonably) that the type of metal does not affect your result, only the mass or size. Which balls do you need to compare to perform this test?

   a) 1 and 2   b) 1 and 3   c) 2 and 3   d) all 3 needed   e) test cannot be done as stated

7. For the previous question, you are trying to test the effect of mass on the ball's final speed.
   a. What property of the balls do you want to vary between the different balls?

   b. What outcome are you measuring?

   c. What thing(s) are you trying to keep the same (constant)?

8. Come up with a logical argument why your answers for the previous question test the effect of mass on the ball's final speed. Remember that slight variations can make you less confident in the logic of your test.

NOW COMPARE YOUR ANSWERS TO THE REST OF YOUR GROUP

Interpret the Tests: First individually, then compare.

9. If the averages of the final speeds you get for several trials are: Ball 1 = 2 m/s, Ball 2 = 2 m/s, Ball 3 = 3 m/s, then this test argues the final speed depends on what properties of the ball?

   a) mass   b) size   c) mass and size
   d) neither mass nor size   e) cannot determine given this information

10. If the averages of the final speeds you get for several trials are: Ball 1 = 2 m/s, Ball 2 = 2 m/s, Ball 3 = 2 m/s, then this test argues the final speed depends on what properties of the ball?

   a) mass   b) size   c) mass and size
   d) neither mass nor size   e) cannot determine given this information

The Scientific Method

"Science is simply common sense at its best, that is, rigidly accurate in observation, and merciless to fallacy in logic." –T. H. Huxley

Evaluate the Experiments:

11. Evaluate the experiment done by Emily Rosa on "therapeutic touch". Watch the youtube video: "STOSSEL TESTING THERAPEUTIC TOUCH" and you can search the Internet for more information, if needed. Here's what you need to answer:
    a. What was the claim that was being tested?

    b. How good of a test was it: did it adequately minimize other possible factors influencing the result?

    c. What conclusion(s) does this test support?

12. Evaluate the experiment we conducted on your daily horoscope?
    a. What was the claim that was being tested?

    b. How good of a test was it: did it adequately minimize other possible factors influencing the result?

    c. What conclusion(s) does this test support?

13. Why did the previous two experiments blind the subjects and/or researchers from knowing the results ahead of time and we didn't necessarily need that when rolling the ball down the ramps?

14. People are usually more persuaded by anecdotes (personal stories) than they are studies. How well do anecdotes minimize other possible factors influencing the results?

WRITE THESE DOWN ON A WHITEBOARD AND PREPARE TO DISCUSS THEM AS A CLASS

CRITICAL THINKING CLOSING REMARKS

15. Work through the following three questions ON YOUR OWN. After 5 minutes, compare answers with your table. Correct your work.

  a. A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost? _____ cents

  b. If it takes 5 machines 5 minutes to make 5 widgets, how long does it take 100 machines to make 100 widgets? _____ minutes

  c. In a lake, there is a patch of lily pads. Every day, the patch doubles in size. If it takes 48 days for the patch to exactly cover the entire lake, how long would it take for the patch to cover only half of the lake? _____ days

16. What lesson(s) can be gained from the previous set of questions? Be prepared to share with the entire class.

17. What is intuition? How does an individual gain intuition on some topic or area of expertise or do you have to always have it? When is it useful and when is it not?

18. Which is mathematics closer to: intuition or analytical reasoning? How does mathematics relate to logic? Are they the same thing? Does one use the other? Is one an example of the other? How do they come up with the rules for algebra, geometry, trigonometry, etc.?

19. What are some basic, easy-to-remember questions you can ask to make yourself think more analytically when presented with new information?

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