

Misconceptions in Science :

Paresh K Joshi

Homi Bhabha Centre for Science Education,
Tata Institute of Fundamental Research

PLAN OF TALK

- What is a Misconception?
- Experiences of interactions with teachers/students
- Some examples.
- Dealing with (mis)conceptions.

What is Misconception?

- Facts away from common perception
- Sounding correct but misleading
- Insufficient understanding with current science
- Outright erroneous

Misconception?

- Misconception is an erroneous conception; mistaken notion (Dictionary.com).
- Typical errors come when students are confused about the limits of applicability of ideas or similes or have incomplete information.
- If not corrected early, these misconceptions can end up with internally inconsistent picture of scientific perspective of the nature.
- Often science fiction plays crucial role in strengthening these “ideas”.
- Students tend to build upon these erroneous ideas and move in a wrong direction
- It can eventually drive students away from science.

SCIENCE FICTION

Black holes and LHC experiment

HONEY I SHRUNK THE KIDS

GOLDEN COMPAS

How to deal with them

- Some of the concepts can be refined/clarified by using experiments or demonstrations.
- Some by thought experiment followed by theoretical equations to lead to some qualitative explanation
- Computer simulation/animation/diagrams
- Drawings to the scale
- Logical arguments with analogies

PERPETUAL MACHINE

Most attractive topic

Students tend to get carried away due to unclear understanding of concepts

If teachers do not stop these ideas, such misconcepts get boost

Need to explain the students/teachers proper concepts, allow them to try it out, collect statistics/data etc

Power source -> two DC motors
-> Gear system
-> Another 2 DC motors (generators)
CLAIM

More power generated than the input power

Collection of data is the eye-opener

PROBLEM : MOIST AIR IS HEAVIER/LIGHTER THAN DRY AIR

Common conclusion : air *with* moisture has to be heavier than air without moisture

My effort : Carry out simulation.

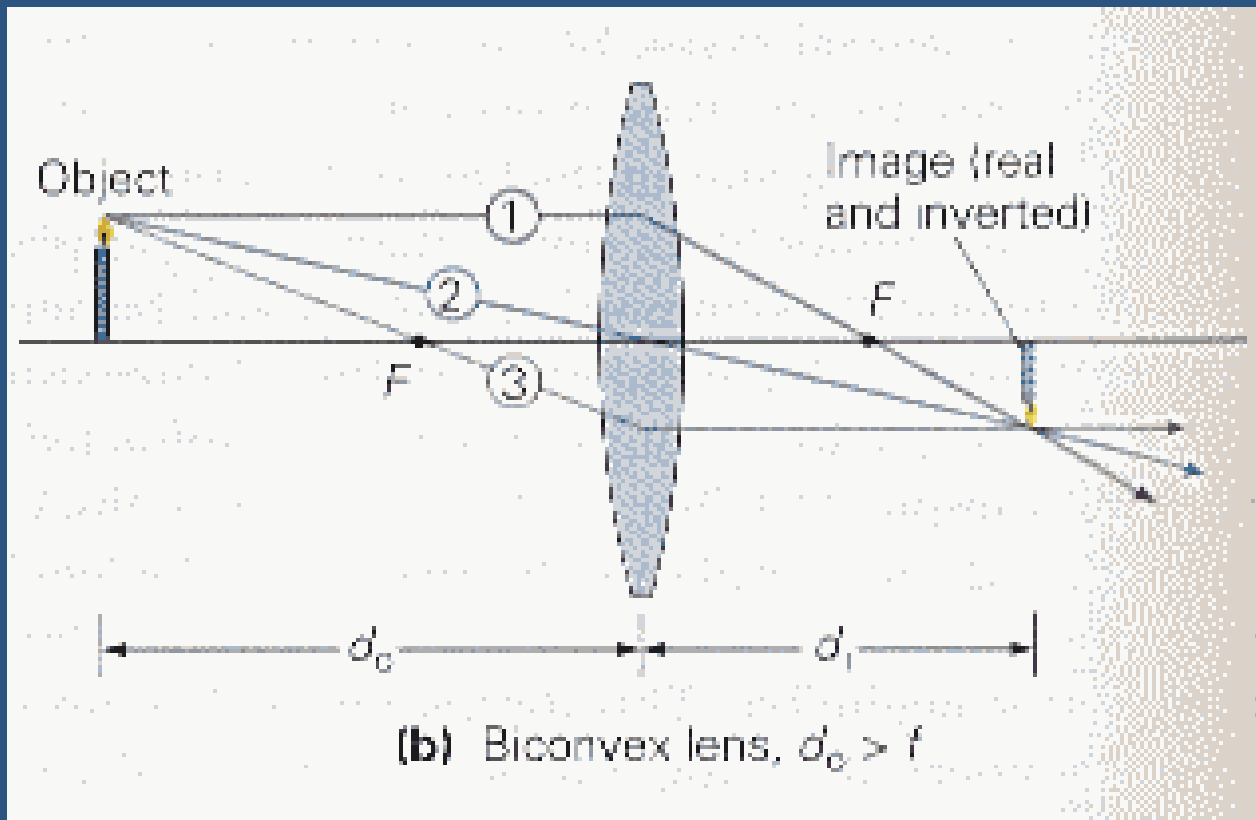


WRONG



BETTER

FUZZY!



Oxygen and Nitrogen together make up more than 90% of atmosphere

So on average the total weight of unit volume reduces with introduction of water molecule

Hence moist air is lighter than dry air.

PROBLEM : ICE SKATES MELT THE ICE ON SURFACE BY PRESSURE

Common explanation : pressure lowers the melting point of ice
resulting in thin layer of water, allowing skater to skate

Problem with explanation : It can be shown theoretically that the
pressure applied is not sufficient to melt the ice

Ice melts under pressure?

$$dP/dT = L/T\Delta V$$

L=latent heat of water = 330 kJ/Kg

ΔV = change in volume of water. 1kg of water freezes to make 1.1 lt of ice i.e. .1 lt = $100 \text{ cm}^3 = 100 \times 10^{-6} \text{ m}^3$ per kg = $10^{-4} \text{ m}^3/\text{kg}$

$$T = 273 \text{ }^\circ\text{K}$$

If a human weights 100 kg, \rightarrow Force of 1000N
area of contact; (50 mm length, 2mm width) $\rightarrow 100 \text{ mm}^2$
pressure is $1000\text{N}/100 \text{ mm}^2 = 1000\text{N}/.01 \text{ m}^2 = 10^7 \text{ N/m}^2 = 10^7 \text{ Pa}$

$$dT = (10^7) \times (273) \times (10^{-4}) / (330 \times 10^3) = 0.83 \text{ }^\circ\text{K}$$

As per Wikipedia, for the ice skating arenas, where the ice is maintained at -7°C , we would require almost a ton of weight to melt the ice.

Pressure effects melting point. BUT ice will melt only if close to 0°C

A claim : A wire and two weights on ice cube. But the melting is due to “hotter” wire due to surrounding

The reduction of friction is due to liquid water which is few molecules thick

Conclusion : the real reason is deeper than just the pressure effects. *Experiment in planning stage.*

PROBLEM: FEEL FOR DIMENSIONS OF SOLAR SYSTEM AND ATOMS

This results in students having several ideas about earth and solar system which are untrue

The lack of feeling for dimensions leads to unphysical concepts in the mind of the students. This has been seen very regularly in science exhibitions

Launch of satellite which can LIGHT UP NORTH POLE IN WINTER!!

My effort : To explain the atomic and solar systems to the scale (to the best of my abilities)

Conclusion

- Students have *plenty of* misconceptions due to insufficient understanding of ideas. This may arise due to unsatisfactory explanation or confusion in comprehension due to lack of attention.
- Students need to be made aware of as clearer concepts as possible
- This will help curtail students going further in science with as consistent picture as possible

Students at Olympiad level were tested.
Number of students who were asked this question: 205
Number who answered correctly : 98
More than half could not “see” the fallacy in fiction

Number, who answered wrong : 70
Those who did not attempt : 37

Examples in Biology: Photosynthesis is a one step process (from *World Applied Sciences Journal 3, p283 (2008)*)

Current explanation: indicates as one step process

Photosynthesis in day, respiration in night

Humans give out carbon-dioxide, plants give out oxygen

Sunlight is used for many other processes besides mixing water with carbon-dioxide to produce glucose. These are also called PHOTOSYNTHESIS

Besides chlorophyll, some other enzymes and organic compounds are also required for the generation of glucose

Glucose produced is not “free” glucose but part of several products?

Conclusion: The current explanation needs to be amended with appropriate additions.

Misconceptions of children

- Flow of charges in AC and DC
- Flow of charges on the surface of conductors
- Most of the textbooks talk of flow of current from positive to negative terminal. It is actually flow of charge.
- Ben Franklin's kite was struck by lightning?
- Any quantity can be measured as accurately as one wants e.g. you can infinitely magnify a picture to see an atom!

Relativistic Concepts

- What we see in space is not from “now”
- Things are not “simultaneous”
- Time flows at “same rate” in range of our perception. But is it true throughout the Universe?
- ?????????? What's next?

Thank You