

Appendix

A selection of commonly held misconceptions in physics

An asterisk has been added to propositions that the author once thought to be true, however briefly, in childhood or later, either because he made them up or parroted something he read in a book without thinking about it. The items are in semi-random order as they occur in the brain, to discourage those who want to categorize.

Compressed air is springy due to molecular repulsion.*

That is what it feels like to compress air in a syringe. The air pushes back like a spring. If air was a collection of stationary molecules then molecular repulsion is a reasonable assumption. The fact that air is a wildly thrashing collection of molecules in violent random motion (average speed ~400 m/s) that are in collision with the walls of the container is not intuitively obvious.

Clouds float.*

Helium balloons float so why not clouds? Clouds are made of droplets of water and/or ice crystals that fall slowly in air due to air resistance and their very small size. In perfectly still air without upward convection a cloud will fall to the ground in a day or so.

A lottery win reduces the chance of winning again and throwing five heads in a row lowers the chance of throwing another one.*

Independent events have the same probability of occurrence without reference to what has gone before. Random events may cluster. Clusters of two are more common than clusters of three or more.

Gunshots can be heard on the Moon.*

No air: no sound.

Putting a towel over the cap of an unopened water bottle increases friction and makes it easier to open.*

Not so. The thick towel (doubled works better) increases the effective radius of the cap and allows more torque to be applied with the same force.

There is no gravity in orbit.*

Cricket ball sized drops of water drift around inside an orbiting space station because the whole assembly is in free fall in the gravitational field. If you don't follow that argument - never mind - leave it for the physics types.

Drivers change gear as they pass the race commentator's box.*

The engine sounds drop in pitch due to the Doppler effect.

Bulbs convert electricity to light.

Bulbs convert electrical energy to heat and light energy. Electricity is a subject like astronomy and cooking, not a substance.

Optical fibers are hollow.

Diagrams showing rays reflecting internally may suggest that, and calling an optical fiber a light-pipe doesn't help.

Birds have insulated feet.

A bird on a wire does not complete a circuit.

Animals are mammals.*

A spider is an animal, not a plant.

The sun is closer in summer.

The summer is hotter. Earth's orbit is elliptical. A closer sun would be hotter. All true statements that do not lead to the conclusion.

Earth rotation causes wind.

This one belongs in the Flat Earth Society's manual of meteorology. Global wind systems that are driven by convective heating are deflected because of rotation, giving the North East trade winds etc..

Europeans thought the Earth was flat in the time of Columbus.*

They didn't.

You can see all of yourself in any mirror if you move back.*

It really does help to have a look.

The adjustable lens in the eye focuses light on the retina.*

Diagrams in books sometimes do indicate just that, neglecting the 95% convergence at the cornea. The lens provides fine adjustment only and is not the principle means by which the image is formed.

Shading part of a lens shades part of the image.*

Every part of a lens acts like a full lens of reduced aperture.

When a ball bounces the height of the bounce reduces each time because energy is converted to sound.*

Kinetic energy is lost during the impact as heat. Sound is a factor, but an insignificant one at something like 0.1 %. The confusion arises because our hearing is so sensitive. We notice the sound but not the heat generated in the ball.

There are two speakers in a typical box because woofers are good for radiating long wavelengths and tweeters are better for short ones.

The speakers are optimized for their frequency ranges but that is not the reason for having the two speakers. A tweeter, like an earphone, radiates low frequencies when the back wave is prevented from interfering with the front wave by putting it in the ear.

A throat full of helium raises the pitch of your voice.*

Not true. The timbre (harmonic structure) of the voice is altered which makes one sound like Donald Duck but the pitch, determined by the frequency of vibration of the vocal lips, is largely unaltered.

The speed of surface waves depends on the density of the liquid.

The speed of ripples on mercury and water is the same. (The restoring force for capillary waves, with wavelengths of a mm or less, is surface tension not gravity dependent and the speed varies with the liquid.)

Because the density is increased the speed of sound in salt water is lower than in fresh water.*

The speed of sound in solids and liquids depends on two factors, the density, and the bulk modulus of elasticity. Increasing the salt concentration increases the bulk modulus and increases the speed of sound. Increasing the pressure has the same effect. The speed of sound in the oceans increases steadily below about a kilometre.

Sound does not travel well in water because I can't hear the pool-side music when I put my head under water.*

Sound above the water reflects at the surface but sound travels very well under water over long distances, five times faster than in air, and with very little dispersion. When we put our heads under water sound does not enter the inner ear in the normal way (transmission from water to air is very low) but reaches the inner ear by bone conduction in the skull. It is said that familiarity (practice) improves the quality of sound perceived in this way.

Hoof-beats and trains can be heard at greater distances in the ground (by putting ones head to the ground) than in the air because sound travels faster in solids.

Not at all. Sounds can be heard at greater distances principally because there is less attenuation in the ground. The effect has nothing to do with speed of propagation.

The more dense a transparent material, the lower the velocity of waves passing through it, and the higher the refractive index.*

True when comparing the refractive index of window-glass and lead-glass (Waterford crystal) but not always true. The speed of sound in a substance is related to both restoring force and physical density, and the speed of electromagnetic waves is not simply related to density either.

If velocity is zero, acceleration is also zero.*

People also say "... accelerate faster ...". Acceleration is a rate of change of velocity, not to be confused with velocity.

Acceleration in MKS units is properly written as m/s/s.*

Not properly, if by properly we mean consistently. Language has exceptions. Asians learning English as adults are disturbed to find that plurals in English take an 's', except when they don't. Mathematics in contrast is constructed without exceptions in notation. The quotient x/x equals 1 (agreed?). The expression $m/s/s = m$. That's what's so nice about mathematics - consistency.

Gravitational force on the moon is one sixth of what it is on the earth.*

The force due to gravity The gravitational field strength, g , is an acceleration, not a force.

A lunch-box sized 12 Volt dry cell will start a car.*

That is a reasonable assumption for a person who doesn't know the current limiting effect of internal resistance and the difference in that respect between a dry cell and a lead-acid battery.

A larger battery of the same Voltage will make a bulb brighter.*

It might, not because it is larger, but because it has a lower internal resistance. A small secondary effect is mistaken as a general principle.

Water is a good electrical conductor.*

Floodwater leads to electrocutions, hence the misunderstanding.

The North magnetic pole is in Canada.*

The definition of the North Pole of a compass needle is a north-seeking pole (geographic north). Unlike poles attract. The magnetic pole in Canada is a South Pole.

Humid air is heavier than dry air.*

A reasonable assumption by analogy for those who think water dissolves in air water like salt dissolves in water, and those who think that air soaks up water like a sponge. Water vapour (molecular weight of 18) is added to air that is mostly nitrogen (molecular weight 28) with no local alteration in pressure. The lighter gas in the mix makes the density of humid air lower than the density of dry air. On a large scale, atmospheric pressure is lowered at ground level by water vapour in the column above, hence the barometer used in many places to predict the approach of a cyclone and the onset of wet weather.

Clay absorbs water.*

Think about it. A bottle of dry sand or dry stones will take 40% water by volume. The water goes into the spaces between the stones in both cases. Clay is very fine sand.

CD's reflect rainbows.

A CD is a circular diffraction grating.

Nuclear power generation is more dangerous than coal generation.*

Few people have been killed by nuclear accidents, but hundreds of coal miners die every year from being buried alive and many more die from lung diseases. Perhaps the misunderstanding occurs because people think only of themselves and are mistaken about the health risks of background radiation.

Hydro power generation is safe.*

Hydro dams are built across mountain valleys in earthquake prone regions of the world. Large earthquakes are unpredictable and rare. People forget that at some time over the next century one or more dams will suddenly burst and the towns downstream will go out to sea at a hundred kilometres an hour on a roaring wall of water.

Hand-phones cause cancer of the brain.

Because hand-phones emit microwaves they heat the brain like a microwave oven, but one or two milli-watts (about one millionth of the power radiated inside a microwave oven) does not supply a significant amount of energy per second. This belief is in the same category as believing drinking mercury and/or kerosene will cure all diseases and

Microwave ovens are dangerous.*

They would be dangerous if they leaked microwaves: generally they do not.

Living under power lines is a health risk.

There is no known mechanism by which very low frequency electromagnetic radiation could cause tissue damage.

Telephone transmission is analog and internet and fax transmission is digital.*

Both telephone and fax signal transmissions before about 1980 were analog. Since then gradual conversion and replacement has taken place. Both transmissions are now digital with more simultaneous telephone conversations on the same cable, and faster higher resolution fax transmission.

Plants absorb food through the roots.*

The confusion between food (sugars made by photosynthesis) and nutrients (ions) is widespread.

A fly sees a multiple image.*

The idea that a fly sees set of images is widespread and firmly held - but think about it. The confusion arises because people think that the eyes act independently of the brain. Your retina has millions of receptors from which the brain compiles an image in many separate processes. The fly has sensors distributed over many components of a compound eye but the principle is the same. Sensory information from many receptors is compiled in the brain. The sensor arrangement makes the image sensitive to movement (as is our peripheral vision). If you want to catch a fly move very slowly: it might not see you coming, or move very fast with a fly-swat.

Tension is a vector.*

Tension or compression (of a spring) is a scalar.

You can weigh air by simply comparing the weight of a full balloon with the empty balloon.*

A full balloon weighs more because of the compression of the air inside.

Eclipses of the Moon are more common than eclipses of the sun.*

Eclipses of the Moon are more frequently visible from a given location.

Compressed air cars will provide CO₂ emission-free transport.

Something has to do the compressing. We get nothing for nothing.

The inverted image seen in a water drop is inside the drop.*

Even some experienced photographers think that. The drop is a convex lens that forms a real inverted image on the near side of the lens. Drops on leaves in sunlight may focus a hot spot on the leaf.

The reflected image in a spherical soap bubble is on the surface.

The reflection is upright and inside. Not a lot of people know that.

The sun sets due west.

The statement "The sun sets in the west" is taken too literally.

A planet has a countable number of moons.*

Numbers are published, but there is no easily defined limit to the size of an orbiting rock that would count as a moon.

High relative humidity makes you feel 'sticky'.*

High relative humidity coupled with high ambient temperature makes people feel sticky, but by itself relative humidity is not a good indicator. Air conditioners lower temperature and remove water from the air, but often the relative humidity inside is higher than outside. A better subjective measure of humidity is the dew point which is necessarily below ambient temperature. A dew point of 25 Celsius is uncomfortable, and 28 Celsius is oppressive.

Cool airflow over hot soup in a spoon cools it.*

Breath is above room temperature and has more water vapour than ambient air. The soup is cooled primarily by assisted evaporation of the hot liquid. (It would be interesting to try the cooling effect of the airflow from a hair dryer.)

Heat rises.*

Hot air and hot water rise due to buoyancy forces. Convection is heat transport by fluid flow.

The temperature of ice is zero degrees C.*

Melting ice cubes in water may be close to zero Celsius but ice can be at any lower temperature.

The terms *loudness* and *amplitude* applied to sound are interchangeable.*

Loudness is subjective, on a log scale with respect to intensity (amplitude squared). The layman does not distinguish the terms and thinks loudness and amplitude are the same.

Longer organ pipes have lower pitch because they contain longer wavelengths.*

Long pipes may contain high intensity upper harmonics. The pitch is set by the frequency of the lowest frequency harmonic, (whether or not it is present) but many believe that the pitch is set by the frequency of the dominant harmonic.

The roar that we hear when we place a seashell next to our ear is not the ocean, but rather the sound of blood surging through the veins in the ear.

That might contribute a little but try holding a shell to your ear in a completely quiet room - like a recording studio. Nothing. The roar is mostly resonating room noise in the shell.

The big bang is a well-established fact.*

More an article of faith than a well established fact.

Evolution is just a theory.*

The implication is that evolution is not a sensible alternative to creationism. It is perhaps the other way round.

Nuclear reactions are not affected by temperature.*

The statement is not true. If it were stars would not be stable.

The near point of the eye is well defined at 22 cm.*

It is for an average human eye of age 40, otherwise it is not.

Only mirrors reflect light.

The statement that only mirrors reflect light is never made in books but somehow children get that idea.

We make sounds of speech with our vocal chords.*

We make the sounds of speech by changing the shape of a resonant cavity made by the mouth and the tongue. Vocal chords are just lips that generate a steady sound that may vary in pitch as air is forced between them.

A torch uses up the energy in a battery.

The notion that a flat battery goes flat when the energy is used up has always amused me.

Electricity is kept in wires by insulation.

Electricity (a subject) is confused with electric charge.

Interference in thin films gives iridescent beetles and butterflies their colour.*

The colour of beetles and butterflies is not dependent on the angle of incidence and is due to complex multi layered (photonic) structures.

Increasing temperature always leads to expansion.

There are exceptions: nylon and type metal for instance.

Good conductors of electric current are not transparent.*

Indium tin oxide is an important exception and there are many others.

Metals are all good heat conductors.*

We make coffee spoons from stainless steel rather than copper or silver because stainless steel is durable and not a good conductor of heat.

Only metals can become superconducting at low temperatures.*

This one is rather like the assumption that all swans are white.

Stars cannot be seen in the sky at noon.*

Venus (a planet) is easily seen at noon if you know where to look'.

All solids have well defined melting points.

A glass does not.

A gas is always less dense than its liquid form.*

Jupiter is thought to have no solid surface transitioning from liquid methane to a gas below.

Red light has a wavelength of 640 nm.*

*Sometimes language is not as precise as we might wish. What we see as red extends over a range of wavelengths - not just 640 nm - and **red** is not a property of light. Red is a physiological response to photon energy exchanged in the retina. When light enters water (the eye) and changes wavelength it does not 'change colour'.*

There are seven rainbow colours.*

There are six broad divisions perceived by us in the solar spectrum ROYGBV. The large drop rainbow approaches the spectral colours. Remember also that colour perception is a mental interpretation of information gathered in the eye with three types of sensors that peak in the red, green and blue. Colour is a property of our visual system, not a property of light.

The primary colours are red, blue and yellow.

The mistaken assignment comes from art teachers who mix paints. The primary colours in addition (lights) are red, green and blue. The colours of paints are the secondary colours, magenta, yellow and cyan.

Electrons orbit the nucleus.*

Electrons are not particles and do not orbit in the usual sense. The angular momentum of the ground state of the helium shells is zero

Mass and weight are the same things.*

The football team is weighed (sic) in kilograms. Mass is regarded as a synonym of weight, when strictly speaking mass is a synonym of inertia. The term 'massed' has been used more frequently in recent years. Perhaps the language is finally on the move.

Heat flows.*

A remnant from the days when all universities taught that heat was a fluid that could be beaten out of things. The word has remained in the language. Heat is transferred in a solid, by the spread of molecular vibrations.

Heat and temperature are the same.

The classic mistake is to think that a hot cup of coffee possesses more heat energy than an iceberg. Supplying heat does raise temperature: except when heat melts ice in a pot of water at zero degrees Celsius etc.

Energy and force are the same things in different applications.

The confusion is disclosed by asking people if they think that drinking coke will increase the force of a person's grip. Many do.

If an aircraft door blows out, passengers may get sucked out.*

Suction is not a force: 'blown out' if standing against the door, is a more accurate description.

The force of gravity is weaker on the moon.*

Gravity (properly defined as gravitational field strength) has the units of acceleration, not force.

Scientists are smarter than ordinary people.*

Even some scientists might believe that: until their wife leaves and they find they can't fold a fitted sheet neatly or work the washing machine. The truth is that people function best in their areas of expertise.