Teaching Challenges

FALL SEMESTER

Misconceptions

Courtesy of Chuck Hollocker

Student Misconceptions about Physics

The following is a list of preconceived notions and misconceptions often possessed by high school students entering "Introductory Physics."

These represent additional barriers to student learning and need to be "un-learned."

I have listed them as ***false*** **statements**.

LIES !! Nothing but lies.

OVERALL / KINEMATICS

1) History has no place in science.
2) Two objects side by side must have the same speed.
3) Acceleration and velocity are always in the same direction.
4) Velocity is a force.
5) If velocity is zero, then acceleration must be zero too.

FALLING BODIES

1) Gravity only acts on things when they are falling.
2) Heavier objects fall faster than light ones.
3) Acceleration is the same as velocity.
4) The acceleration of a falling object depends upon its mass.
5) The forces on two falling bodies is always the same.
6) Freely falling bodies can only move downward.
7) There is no gravity in a vacuum.

NEWTON'S LAWS : INERTIA

1) Inertia is the force that keeps objects in motion.
2) Forces are required to maintain motion with constant velocity.
3) Inertia deals with the state of motion (at rest or in motion).
4) All objects can be moved with equal ease in the absence of gravity.
5) All objects eventually stop moving when the force is removed.
6) If two objects are both at rest, they have the same amount of inertia.
7) Velocity is absolute and not dependent on the frame of reference.

NEWTON'S LAWS: A=F/M

1. There is no connection between Newton's Laws and kinematics. This is a new unit.
2. Equilibrium means that all the forces on an object are equal.

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3. Only animate things, like people and animals, exert forces. Passive ones, like tables and floors, do not exert forces.
4. Once an object is moving, heavier objects push more than lighter ones.
5. When you apply a force with your hand, your hand still acts on an object after the object leaves it.
6. Friction can act in the direction of motion.
7. Constant speed means there is no acceleration.
8. Velocity and speed are the same thing.
9. Distance and displacement are the same thing.

NEWTON'S LAWS: FORCE PAIRS

1. Action-reaction forces act on the same body.
2. The normal force on an object is equal to the weight of the object by the 3rd law.
3. The normal force on an object always equals the weight of the object.
4. Equilibrium means that all the forces on an object are equal.
5. Equilibrium is a consequence of the 3rd law.
6. Newton's 3rd law can be overcome by motion (such as by a jerking motion).
7. Some forces, like gravity, act alone.

GRAVITATION

1. The Earth's spinning motion causes gravity.
2. The gravitational force is the same on all falling bodies.
3. The gravity that acts on an apple is not the same as the gravity that acts on the Moon.
4. The Moon is not falling.
5. The Moon is not in free fall.
6. There are no gravitational forces in space.
7. The gravitational force acting on the Space Shuttle is nearly zero.
8. The gravitational force acts on one mass at a time.
9. The moon stays in orbit because the gravitational force on it is balanced by the centrifugal force acting on it.
10. Weightlessness means there is no gravity.

CONSERVATION OF ENERGY

1. Energy is not related to Newton's laws. This is a new unit.
2. Energy is a force.
3. Energy gets used up or runs out.
4. Something that is not moving can't have any energy.
5. A force acting on an object does work even if the object does not move.
6. Energy is destroyed in transformations from one type to another.
7. Energy can be recycled.

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8. Gravitational potential energy is the only type of potential energy.
9. When an object is released to fall, the gravitational potential energy immediately becomes all kinetic energy.

CONSERVATION OF MOMENTUM

1. Momentum is the same as force.
2. Momentum and kinetic energy are the same.
3. Momentum is not a vector.
4. Conservation of momentum applies only to collisions.
5. Moving masses, in the absence of gravity, have no momentum.
6. The center of mass of an object must be inside the object.
7. Center of mass is always the same as the center of gravity.
8. Momentum is not conserved in collisions with "immovable" objects

CIRCULAR MOTION

1. Circular motion does not require a force.
2. Centrifugal forces are real.
3. An object moving in circle with constant speed has no acceleration.
4. An object moving in a circle will continue in circular motion when released.
5. An object is circular motion will fly out in a curve when released.

ANGULAR MOMENTUM

1. Any force acting on an object will produce a torque.
2. Objects moving in a straight line do not have angular momentum.
3. Torque is the same as force and is in same direction.
4. Angular momentum is not a vector.
5. The direction of angular momentum is in the direction of the linear momentum.

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KEPLER'S LAWS

1. Planetary orbits are circles.
2. The speed of a planet in orbit never changes.
3. An object must be at both foci of an elliptical orbit.
4. All the planets move in their orbits with the same speed.
5. No work is done on orbiting planets by the sun.
6. The orbits of the planets lie precisely in the same plane.
7. All the planets revolve about sun with the same period.
8. Revolution is the same as rotation.

NAVIGATING IN SPACE

1. Spacecraft travel in straight lines from one planet to another.
2. Spacecraft can be launched anytime to travel from one planet to another.
3. Spacecraft are not affected by the sun.
4. Motion relative to Earth is the same as motion relative to the sun.
5. Jets can fly in space.
6. Spacecraft in orbit about Earth don't follow a sinusoidal path relative to the sun.
7. Rockets need something (air) to push against.

CURVED SPACE & BLACK HOLES

1. Space is not something.
2. Black holes are big.
3. Light always travels in straight lines.
4. Black holes exert a greater gravitational force on distant objects than the star from which it was formed.
5. Observations made in a gravitational field differ from those made in a system with constant acceleration.
6. Things in space make sounds.
7. If the Sun were to become a black hole, the Earth would get sucked into it.

TEMPERATURE AND GAS LAWS

1. A cold body contains no heat.
2. There is no limit on the lowest temperature.
3. An object has no mass at absolute zero.
4. Sweaters will make you warmer.
5. Cold can flow.

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6. Gases can be compressed to zero volume.
7. Heat and temperature are the same thing.
8. Heat and cold flow like liquids.
9. Pressure is the same as force.
10. Skin is a good thermometer.

HARMONIC MOTION

1. The period of oscillation depends on the amplitude.
2. The restoring force is constant at all points in the oscillation.
3. The heavier a pendulum bob, the shorter its period.
4. All pendulum motion is perfect simple harmonic motion, for any initial angle.
5. Harmonic oscillators go forever.
6. A pendulum accelerates through the lowest point of its swing.
7. Amplitude of oscillations is measured peak-to-peak.
8. The acceleration is zero at the end points of the motion of a pendulum.

WAVES

1. Waves transport matter.
2. There must be a medium for a wave to travel through.
3. Waves do not have energy.
4. All waves travel the same way.
5. Frequency is connected to loudness for all amplitudes.
6. Big waves travel faster than small waves in the same medium.
7. Different colors of light are different types of waves.
8. Pitch is related to intensity.

WAVE NATURE OF LIGHT

1. Light just is and has no origin.
2. Light is a particle.
3. Light is a mixture of particles and waves.
4. Light waves and radio waves are not the same thing.
5. In refraction, the characteristics of light change.
6. The speed of light never changes.
7. Rays and wave fronts are the same thing.
8. There is no interaction between light and matter.
9. The addition of all colors of light yields black.
10. Double slit interference shows light wave crest and troughs.
11. Light exits in the crest of a wave and dark in the trough.
12. In refraction, the frequency (color) of light changes.
13. Refraction is the bending of waves.

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MICHELSON-MORLEY EXPERIMENT

1. A null result means experiment was a failure.
2. The aether exists because something must transmit light.
3. Relativistic effects (length contraction) is the reason why no difference in the speed of light was observed.

SPECIAL RELATIVITY

1. Velocities for light are additive like for particles.
2. Postulates cannot be used to develop a theory.
3. Length, mass, and time changes are just apparent.
4. Time is absolute.
5. Length and time only change for one observer.
6. Time dilation refers to 2 clocks in 2 different frames.
7. Time dilation and length contractions have not been proven in experiments.
8. There exists a preferred frame of reference in the universe.
9. A mass moving at the speed of light becomes energy.
10. Mass is absolute, that is, it has the same value in all reference frames.

ELECTRIC FIELDS AND FORCES

1. A moving charge will always follow a field line as it accelerates.
2. If a charge is not on a field line, it feels no force.
3. Field lines are real.
4. Coulomb's law applies to charge systems consisting of something other than point charges.
5. A charged body has only one type of charge.
6. The electric field and force are the same thing and in the same direction.
7. Field lines can begin/end anywhere.
8. There are a finite number of field lines.
9. Fields don't exist unless there is something to detect them.
10. Forces at a point exist without a charge there.
11. Field lines are paths of a charges motion.
12. The electric force is the same as the gravitational force.
13. Field lines actually radiate from positive to negative charges and convey motion.
14. Field lines exist only in two dimensions.

MILLIKAN EXPERIMENT

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1. Charge is continuous and can occur in any amount.
2. An electron is pure negative charge with no mass.
3. Oil drops are electrons.
4. The scientific method is pure and absolute.
5. Scientists always stumble on discoveries.
6. Millikan measured the mass of the electron.

EQUIPOTENTIALS AND FIELDS

1. Voltage flows through a circuit.
2. There is no connection between voltage and electric field.
3. Voltage is energy.
4. Equipotential means equal field or uniform field.
5. High voltage by itself is dangerous.
6. It takes work to move a real charge on an equipotential surface.
7. Charges move by themselves.
8. Sparks occur when an electric field pulls charges apart.

POTENTIAL DIFFERENCE AND CAPACITANCE

1. A capacitor and a battery operate on the same principle.
2. A potential difference is only on plates of a capacitor and not in region between.
3. Charge flows through a dielectric, such as glass.
4. Designations of (+) and (-) are absolute.
5. Q = CV is a basic conceptual law.
6. No work is required to charge a capacitor.
7. There is a net charge on a capacitor.
8. The capacitance of a capacitor depends on the amount of charge.
9. A positive charged capacitor plate only has positive charges on it.
10. Charges flow through a capacitor.

SIMPLE DC CIRCUITS

1. Resistors consume charge.
2. Electrons move quickly (near the speed of light) through a circuit.
3. Charges slow down as they go through a resistor.
4. Current is the same thing as voltage.
5. There is no current between the terminals of a battery.
6. The bigger the container, the larger the resistance.
7. A circuit does not have form a closed loop for current to flow.
8. Current gets "used up" as it flows through a circuit.
9. A conductor has no resistance.
10. The resistance of a parallel combination is larger than the largest resistance.

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11. Current is an excess charge.
12. Charges that flow in circuit are from the battery.
13. The bigger the battery, the more voltage.
14. Power and energy are the same thing.
15. Batteries create energy out of nothing.

MAGNETIC FIELDS

1. North and south magnetic poles are the same as positive and negative charges.
2. Magnetic field lines **start** at one pole and **end** at the other.
3. Poles can be isolated.
4. Flux is the same as field lines.
5. Flux is actually the flow of the magnetic field.
6. Magnetic fields are the same as electric fields.
7. Charges at rest can experience magnetic forces.
8. Magnetic fields from magnets are not caused by moving charges.
9. Magnetic fields are not 3-dimensional.
10. Magnetic field lines hold you on the Earth.
11. Charges, when released, will move toward the poles of a magnet.

ELECTROMAGNETIC INDUCTION

1. Generating electricity requires no work.
2. When generating electricity only the magnet can move.
3. Voltage can only be induced in a closed circuit.
4. Magnetic flux, rather than change of magnetic flux, causes an induced emf.
5. All electric fields must start on (+) and end on (-) charges.
6. Water in dams causes electricity.

ALTERNATING CURRENT

1. Charges move all the way around a circuit and all the way back.
2. Voltage and current remain constant as in DC circuits.
3. Energy is not lost in a transformer.
4. A step-up transformer gives you something more for less input.
5. Transformers can be used to change DC voltages.
6. Electrical companies supply the electrons for your household current.

WAVE-PARTICLE DUALITY

1. Light is one or the other (a particle or a wave) only.
2. Light can be a particle at one point in time and a wave at another point in time.

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3. Particles can't have wave properties.
4. Waves can't have particle properties.
5. The position of a particle always can be exactly known.
6. A photon is a particle with a wave inside.
7. Photons of higher frequency are bigger than photons of lower frequency.
8. All photons have the same energy.
9. Intensity means that the amplitude of a photon is bigger.
10. The Uncertainty Principle results from the limits of measuring devices.
11. Laser beams are always visible by themselves.
12. Sometimes you feel like a wave, sometimes you don't. (not particularly)

MODELS OF THE ATOM

1. There is only one correct model of the atom.
2. The model we use of the atom is absolutely correct.
3. Electrons in an atom orbit nuclei like planets orbit the sun.
4. Electron clouds are pictures of orbits.
5. Electrons can be in any orbit they wish.
6. Hydrogen is a typical atom.
7. The wave function describes the trajectory of an electron.
8. Electrons are physically larger than protons.
9. Electrons and protons are the only fundamental particles.
10. Physicists currently have the "right" model of the atom.
11. Atoms can disappear (decay).