Questions For Review
Phys-109 Exam 3 (Final)

Topic Check-off List
Be able to describe and give an example for each of the following

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Here are some questions to help you review for the exam:

1. Why does the gravitational force predominate over electrical force for astronomical bodies?
2. What is the origin of the +/- system of naming charge?
3. What part of an atom is positively charged and what part is negatively charged?
4. What is meant when you say that charge is conserved?
5. How is Coulomb’s law similar to Newton’s law of gravitation? How is it different?
6. What do we do when we “ground” an object?
7. What is lightning made of?
8. Why will a balloon that is charged either positively or negatively stick to a neutral wall?
9. Is it dangerous to touch the terminals of a car battery? Why or why not?
10. What are the units for current, potential and resistance?
11. What is a volt equal to?
12. Does voltage produce current or does current produce voltage?
13. What is the effect on current through a circuit when the voltage is doubled? What if both voltage and resistance are doubled?
14. What role do resistors play in an electric circuit?
15. How do you wire ammeters into a circuit? Voltmeters?
16. What has the greatest electrical resistance, wet skin or dry skin?
17. How does an incandescent light bulb work? Why was it difficult for Edison to “invent” such a simple thing?
18. High voltage by itself does not produce electric shock. What does?
19. What is the function of the third prong on the plug of an electric appliance?
20. What’s the difference between DC and AC electricity?
21. True or false: Electrons in a common battery-driven circuit travel at about the speed of light.
22. How is electric power related to current and voltage?
23. How do fuses and circuit breakers keep you safe in your home?
24. Chapter 26 Exercises, (p. 512), #4, 5, 7, 10, 14
25. Chapter 28 Review Questions (p. 557) #1
26. Chapter 31 Exercises (p. 621), #1-4, 6, 9, 27, 28
27. Chapter 33 Exercises (p. 659), #1
28. Chapter 34 Exercises (p. 682), #4, 12, 28, 30, 31, 36
29. Chapter 35 Exercises (p. 717), #2, 4, 16, 18

Answers to Review Questions

1. Stars, planets and other astronomical bodies are electrically neutral. I.e., they contain an equal amount of positive and negative charge. When compared particle by particle, the electrical force is much stronger than the gravitational force, but the force of gravity is all there is for neutral objects.
2. Benjamin Franklin defined the +/- system, which ended up making electrons negative. He was a proponent of the “single fluid” model for electricity and thought that electric charge was a single type of stuff, and that negatively charged objects lacked it while positively charged objects had an overabundance of it.
3. Electrons are negative and the nucleus is positive, containing positively charged protons.
4. Charge is never created or destroyed. It can be moved around, and if present in equal amounts an object will be neutral, but charge doesn’t ever just disappear.
5. When expressed as equations, the laws look very similar. The gravity law looks like
   \[ F_c = G \frac{m_1 m_2}{d^2} \] and Coulomb’s law looks like \[ F_c = k \frac{q_1 q_2}{d^2} \]. Both are inverse square laws for distance. The gravity force depends on the mass of the objects, and the Coulomb force depends on the charge of the objects. The values of the two proportionality constants are quite different, \( G = 6.67 \times 10^{-11} \) and \( k = 9.0 \times 10^9 \). Since \( k \) is so much bigger, the force acting between two one-coulomb charges would be very much greater than the force of attraction between two on-kilogram masses at the same distance.
6. A ground is an electrical entity (place, object) that is able to receive a lot of charge. The ground is a great ground. When a charged object is grounded, the charge will flow into the ground. If a person is touching a high voltage, it would be dangerous to touch a ground because the charge will flow through them into the ground, possibly causing damage to their body. When working inside your computer, it’s important to ground your body so that charge doesn’t build up on you and then zap the sensitive components in your computer.
7. Lightning is a spark. A spark is visible because it is a path of ionized air. When the atoms in the air lose their electrons and the electrons “fall” back into their orbits, they emit light.
8. The charged balloon induces a charge in the wall, drawing the opposite charges near it. Since the opposite charges are then closer to the charged object than the like charges, attraction always wins.
9. Touching a 12-volt car battery with dry fingers is quite safe. The voltage is too low to cause damaging current, in spite of the fact that a car battery contains enough energy to kill a person many times over. If skin is wet its resistance may be lowered substantially, which could make touching the same battery dangerous.
10. Current is measured in amperes. 1 ampere = 1 coulomb/second. Potential is measured in volts. The unit of resistance is the ohm (\( \Omega \)). Which reminds me of a couple important notices: 1) Watt is Ohm’s law and who volted it into existence? Has it met with any resistance in its application? Please respond quickly because my hair is on end and my emotional life has become static while awaiting an answer. 2) Repeal Ohm’s Law! Ohm’s Law was good enough in its time, but that time is past. It is a rankly discriminatory piece of legislation and should be
repealed or severely amended. Current should be directly proportional to BOTH voltage and resistance, or inversely proportional to both, or proportional to neither. And always remember: Resistance begins at ohm!

11. 1 joule/coulomb (energy per charge).
12. In the “water flow” analogy, voltage is the pump that causes the water (current) to flow. A resistor plays the role of a tube of varying diameter, with thin tubes having high resistances.
13. Ohm’s law predicts a doubling of the current when the voltage doubles. If both voltage and resistance are doubled the current would remain the same ($I = \frac{V}{R}$).

14. Resistors limit the current that flows for a given voltage.
15. Ammeters are wired in series with a resistance. Voltmeters are wired in parallel.
16. Dry skin has a higher resistance than wet skin. The danger of electrical shock is much greater in a wet environment, as a result.
17. The filament gets very hot, glowing with a bright white light. It was difficult for Edison to find a filament material that would get very hot and yet last a long time.
18. Voltage is energy per charge, so energy is voltage times charge. The energy of the shock is the dangerous part, so both voltage and charge (or current) is necessary. When you rub your feet on the carpet, your body typically becomes charged up to voltages of over 10000 V, but there’s a very small amount of charge.
19. The third prong connects directly to the ground. Inside the device, this ground wire is connected to its body. So if a “hot” electric wire inside the device somehow becomes connected to its body, a circuit will immediately be established with the ground which will blow the fuse or trip the circuit breaker, protecting users from possible electric shock.
20. DC = direct current. AC = alternating current. DC circuits have charge that flows in a single direction, while AC circuits switch directions. AC electricity in the U.S. is supplied at a rate of 60 cycles per second.
21. False. The electrons themselves typically move quite slowly. When a circuit is first established, the signal of one electron pushing against another moves at about the speed of light, however.
22. In a simple circuit, power = voltage times current. This is the “danger” connection again, since power is the rate that energy is used.
23. When too much current flows in a household circuit the fuse or circuit breaker will break the circuit. This prevents resistive heating in the wires of the circuit, which can cause fires.
24. #4: Radio waves. You should be able to rank the ER spectrum for radio, micro, IR, visible, UV, x-ray and gamma ray. #UV has shorter wavelength and higher frequency. #7: The wave is made of electric and magnetic fields and it’s the fields that wave. They wave by getting stronger and then weaker. #10: Sound requires a medium but light does not. #14: When we see the moon at night, we are seeing light that travels to our eyes through a vacuum.
25. #1: Reflection occurs when a wave bounces off a medium boundary. While traveling through the boundary, some will transmit through into the new medium while some bounces off (partial transmission and reflection). Refraction also occurs when a wave travels into a new medium. If traveling into the new medium at an angle, the transmitted portion of the wave will bend so that it travels in at an angle.
26. #1: Classical physics concerns theories formulated prior to about 1900, consisting of mechanics, optics, electricity and magnetism, and thermodynamics. The modern theories are quantum physics and relativity. #2: Quantized things come in chunks, amounts that can’t be separated. #3: It just is. We didn’t make this stuff up, it’s the way we found nature to be. Blame God if you want to, but the energy of a photon depends on its wavelength. #4: The violet photon has twice the energy of the red photon. Energy is directly proportional to frequency. #6: The blue photons are more energetic, so in order to have the same amount of energy in the beam, fewer blue photons are needed. Therefore the red beam contains the greater number of photons. #9: Ultraviolet light is energetic enough that its photons are capable of ionizing atoms, thus producing the eventually attractive skin damage known as sunburn. #27: $\lambda = h/p$, and as speed increases so does $p$. Therefore the wavelength gets shorter. #28: Small.
27. #1: Gamma rays. Both are electromagnetic radiation.
28. #4: Neutrons have no charge, and there is thus no repulsion (which would be the case for a proton). Electrons are charge opposite nuclei, and would thus hit them more readily, but are too light to make much of an impact. #12: The water inside the reactor core becomes somewhat radioactive, so rather than letting it flow out into the turbine, we keep it sealed inside the inner loop of the reactor. #28: Fission fuel can reach a critical mass and create a nuclear explosion or fizzle. Fusion fuel is just a bunch of hydrogen, with no nuclear reaction danger. #30 1. Fuel is readily available. 2. No radioactive waste products. 3. No danger of runaway reaction- if the fusion reactor cools, the reaction stops. #31: We are sustained in many ways by the energy from the Sun, which comes from fusion. #36: Hydrogen is a great way to store energy, but isn’t found in a chemically reactive state in nature. It has to be separated from water molecules, which requires energy.
29. #2: Nope, there’s no way to sense or measure uniform motion. You can tell you’re accelerating quite easily. The human body feels acceleration, as we’ve all experienced in a car or airplane. A bowl of water would go out of level when it’s accelerated. #4: The light beam would be going c whether measured from the train or the ground. That’s what’s so weird about the light. The bullet in #3 acts like we’d expect things to act, with the train velocity being added to the bullet. #16: No problem- just go really fast. Then the great distance would be length-contracted into something a lot shorter (and the person would age very quickly relative to those left back on Earth). #18: No problem- just have the parent go really fast on an out-and-back trip from Earth. When reunited with his/her son/daughter he/she can be older than them if he/she went far enough and fast enough.