Name: __________________________________________

Exam 03: Chapters 05–07

Instructions
Put your name on this test paper. When you complete the exam, the test paper must be submitted. This exam paper will be returned to you when it is graded.

You may use your calculator and the formula sheet provided. You may not use any additional reference materials.

Respond to each of the exam questions using your clicker. If a numerical answer is required, please express it to the correct number of significant digits, and include the algebraic sign where appropriate. You should also mark on the test paper.

Make sure that all mobile devices are switched off. No devices should be visible on your desk. If your phone rings during the exam, you will be required to turn in your exam and leave the room. You will not be allowed to return and complete any unfinished portions of the exam. You may not use any internet-capable mobile device as a calculator.

๏ Click and mark! Mark your answers directly on the test paper as well as clicking.
๏ There is exactly one correct answer for each question.
๏ Each question is worth 2 points.
๏ There is no partial credit.

Scoring
Each question is worth 2 points. Points: ______________ /100
1. A tone generator creates sound waves with a single frequency. The output can be adjusted for frequency and loudness (intensity level). Which of the following tones would be most difficult for an average person to hear?
A) Frequency = 700 Hz, intensity level = 60 dB.
B) Frequency = 1700 Hz, intensity level = 40 dB.
C) Frequency = 17,000 Hz, intensity level = 20 dB.
D) Trick question; none of these frequencies are audible!

2. You are whispering a snarky comment to your friend in the movie theater, probably about that joker two rows up who won’t turn off his phone. A whispering voice is closest to about 30–35 dB. A) about 30–35 dB.
B) right around 60–70 dB.
C) at least 90 dB.
D) 150 dB, minimum.

3. Your cousin is visiting from Tulsa, and she brought her 3 month old baby. Cute, but colicky. You just got back from the Best Buy, where you bought a cool new digital sound meter. Coincidence? I don’t think so. A) The screaming baby registers no more than 15 dB.
B) Screaming baby comes in at about 30 dB.
C) Screaming baby could hit as high as 90 dB.
D) The baby will probably be screaming at 150 dB or even higher. For hours. And hours.

4. True or false: The electron has exactly the same charge as a proton, except an electron is negative and a proton is positive.

5. True or false: The electron is many times more massive than the proton.

6. A neutron and a proton will be attracted gravitationally. But what is the electrostatic force between the particles?
A) Negative neutrons attract positive protons.
B) Positive neutrons repel positive protons.
C) Neutral neutrons do not attract or repel protons.
D) Neutral neutrons will both attract and repel protons.

7. Every sodium atom has 11 protons in its nucleus. If one electron is removed from to a neutral sodium atom, A) a positive ion is created with a net charge of +11 C.
B) a negative ion is created, and the net charge is -11 C.
C) a positive ion is created with net charge +1.6x10^-19 C.
D) a negative ion is created. The net electrical charge will be -1.6x10^-19 C.

8. To say that charge is quantized means that an object A) can possess any amount of charge; the quantity just needs to be measured.
B) can have fractional amounts of charge from partial particles, i.e., half an electron.
C) can only have whole number of protons or electrons, so there are specific amounts, or quota, of charge that are allowable; you cannot have half an electron.
D) cannot possess any extra charge: the number of negative charges must always equal the number of positive charges in every atom.

9. When you scuffle across the carpet in your socks, you are A) using induction to repel the negative carpet fibers away from your negative socks.
B) using polarization to pull some protons out of the nuclei of the carpet fibers. You accumulate some excess (+) charge.
C) using friction to scrape some negative electrons off the carpet fibers. You accumulate some excess (-) charge.
D) using magic to levitate the neutrons out of the carpet and onto your socks. Accio neutronium!

10. Why are materials like glass or rubber good electrical insulators?
A) Insulators are composed of atoms with no electrons; there are no charges available to move.
B) Insulators are always crystalline; the ordered arrangement of atoms makes it hard to move electrons.
C) Insulators are usually light-colored. Glass or rubber can be made white or light beige, while metallic materials will be darker (gray or brownish).
D) Insulators typically have full outermost electron shells; it is more difficult to pull an electron off, and if you manage to pull one off, the next atom over has no place to put it.

Charge \( q_1 = +1 \times 10^{-4} \text{C} \), and it is located at \( r_1 = 15 \text{cm} \) from charge \( q_2 = -9 \times 10^{-6} \text{C} \). The magnitude (absolute value) of the force is \( F_1 = 36 \text{N} \). Use this information to answer Questions 11–13.

11. True or false: These charges attract each other.

12. True or false: Changing the amount of charge \( q_1 \) will have no effect on the net force between the charges.

13. When the distance between the charges is decreased by a factor of three \( (r_2 = (\frac{1}{3})r_1 = (\frac{1}{3})(15 \text{ cm}) = 5 \text{cm}) \), what is the result? The new force \( F_2 \) is A) unchanged. \( F_2 = F_1 = 36 \text{N} \).
B) decreased: \( F_2 = (\frac{1}{3})F_1 = (\frac{1}{3})(36 \text{N}) = 12 \text{N} \).
C) decreased: \( F_2 = (\frac{1}{3})F_1 = (\frac{1}{3})(36 \text{N}) = 4 \text{N} \).
D) increased: \( F_2 = (3)F_1 = (3)(36 \text{N}) = 108 \text{N} \).
E) increased: \( F_2 = (9)F_1 = (9)(36 \text{N}) = 524 \text{N} \).

14. In the context of physics, what is a field?
A) A field describes the effect something (like a mass or a charge) has on the surrounding space.
B) A field is any region of empty space: the vacuum of interstellar space, for example.
C) A field is the same thing as a force: it is the effect that one object has on another object.

15. An electric field is created by two equal charges fixed in the positions shown on the right. Given that the field lines represent the effect on a positive test charge, what are the signs of the fixed charges?
A) Nothing. The two charges might be any sign at all.
B) Charge \( q_1 \) is (+) and \( q_2 \) is (-).
C) Charge \( q_1 \) is (-) and \( q_2 \) is (+).
D) Both charges must be positive.
E) Both charges must be negative.
16. Electric potential, or voltage, is defined as
   A) electric potential energy per charge.
   B) potential energy per unit of mass.
   C) total charge per total electric potential energy.
   D) total electric current per electron per unit of energy

17. The tabletop van de Graaf generator can develop a voltage as high as several thousand volts.
   A) That’s not possible! A standard household outlet has only about 120V, and it will give you a painful shock.
      The van de Graaf must have a lower voltage than a typical household outlet.
   B) Sure, it sounds dangerous. But the voltage is high because the total amount of charge is tiny. No one gets hurt touching the van de Graaf, even at 1000V!
   C) This is because voltage is defined differently for household circuits. That “120-V” outlet is really delivering about 120,000V to whatever is plugged in.
   D) A van de Graaf generator can produce much higher voltages than household outlets, up to several million volts.

18. One electron with 2J of potential energy has a voltage
   \[ V = \frac{W}{q} = \frac{2J}{1.6 \times 10^{-19} \text{C}} = 1.25 \times 10^{19} \text{V} \]
   A) \( V = 0 \text{V} \)
   B) \( V = 1.6 \times 10^{19} \text{V} \)
   C) \( V = 1.6 \text{V} \)
   D) \( V = 1.6 \times 10^{19} \text{V} \)
   E) \( V = 1.25 \times 10^{19} \text{V} \)

19. One amp (or ampere) of electrical current is defined as
   A) one coulomb of charge per electron.
   B) one electron traveling at a speed of 1 m/s.
   C) one coulomb of charge per second of time.
   D) one electron per m2 of cross-sectional area of wire.

20. How is the direction of electrical current defined?
   A) Current flows from (+) to (–). This is the direction which the actual electrons will move.
   B) Current flows from (+) to (–). This is opposite the direction which the actual electrons will move.
   C) Current flows from (–) to (+). This is the opposite of the direction which the actual electrons will move.
   D) Trick question! There is no standard convention for defining the direction of current flow.

21. True or false: When the switch is closed on a circuit, electrons will pour out of the negative terminal of the battery, and flow completely around the circuit until they pour back into the positive terminal of the battery.
   A) True
   B) False

22. True or false: The electrical resistance of a thinner wire will be greater than that of a thicker wire of the same length made of the same material.
   A) True
   B) False

23. As the temperature of a light bulb filament increases, the electrical resistance of the filament
   A) increases.
   B) decreases.
   C) stays constant.
   D) goes to exactly zero.

24. What is the resistance of an electric blow dryer that draws a current \( I = 13.3 \text{A} \) when connected to a \( V = 120 \text{V} \) household circuit?
   \[ V = IR \implies R = \frac{V}{I} = \frac{120 \text{V}}{13.3 \text{A}} = 9.0 \Omega \]
   A) \( R = 7.5 \Omega \)
   B) \( R = 8.5 \Omega \)
   C) \( R = 8.5 \Omega \)
   D) \( R = 9.0 \Omega \)
   E) \( R = 9.5 \Omega \)
   F) \( R = 10 \Omega \)

25. How much power does this blow dryer use?
   \[ P = IV = (13.3 \text{A})(120 \text{V}) = 1596 \text{W} \]
   A) \( P = 1500 \text{W} \)
   B) \( P = 1600 \text{W} \)
   C) \( P = 1700 \text{W} \)
   D) \( P = 1800 \text{W} \)
   E) \( P = 1900 \text{W} \)
   F) \( P = 2000 \text{W} \)

26. The magnetic force causes opposite poles to
   A) cancel each other.
   B) attract each other.
   C) repel each other.
   D) destroy each other.

27. Which of the following is most responsible for creating the magnetic field of a typical refrigerator magnet?
   A) The orbital motion of protons.
   B) Gravitational attraction between protons and electrons.
   C) Convection currents as the denser metal sinks.
   D) Electrons spinning.

28. Which of the following materials could not be used in its pure form to make a compass needle?
   A) Cobalt.
   B) Aluminum.
   C) Nickel.
   D) Iron.

29. The picture on the right shows the domains of a piece of an iron bar.
   A) This object is definitely not magnetic.
   B) This object is definitely magnetized.
   C) If this object is non-metallic, it’s clearly a magnet. If it’s metallic, it’s not.
   D) The picture as nothing to do with metals or magnetism! The arrows represent the force of gravity on the individual areas of the object shown.

30. What happens if you break a bar magnet into four pieces?
   A) You have four complete magnets, each one having a north and a south pole.
   B) You have four magnets: two with only south poles and two with only north poles.
   C) One magnet has a south pole, one has a north pole, and two pieces are unmagnetized metal.

31. How do you make an electromagnetic wave?
   A) Keep a charged particle (like an electron) completely at rest. Any motion of the particle will collapse the wave.
   B) Keep a neutral particle (a neutron) completely at rest. Any motion of the particle will collapse the wave.
   C) Oscillate an un-charged particle (only neutrons work). The motion of the mass creates an e-m wave.
   D) Oscillate a charged particle (like an electron). The accelerating electron creates the varying E and B fields.

32. Electromagnetic waves are
   A) transverse and require a material medium to propagate.
   B) transverse and do not require a material medium.
   C) longitudinal and require a material medium.
   D) longitudinal and do not require a material medium.

33. The electromagnetic spectrum includes
   A) radio, sound, and seismic waves.
   B) radio, television, and sound waves.
   C) radio, infrared, ultraviolet, and gamma rays.
   D) visible light, but no other types of waves.

34. True or false: Like the sun, you are currently radiating electromagnetic waves. Just at a much lower frequency.

35. True or false: A gamma ray will travel faster through vacuum than visible light, and visible light travels faster than radio waves.
36. Ultraviolet (UV) waves have a much shorter wavelength than infrared (IR) waves. 
   A) UV have lower frequency and lower energy than IR. 
   B) UV have lower frequency and higher energy than IR. 
   C) UV have higher frequency and lower energy than IR. 
   D) UV have higher frequency and higher energy than IR. 
   E) UV and IR have the same frequency and same energy!

37. When sunlight strikes a clear glass windowpane, about 85% of the incident light is transmitted. What happens to the remaining 15% of the incident light? 
   A) It is lost, and 15% of the initial energy disappears. 
   B) It is mostly reflected, but some light will be absorbed. 
   C) It is completely absorbed, because glass cannot reflect light. 
   D) It is also transmitted. 100% of the light must pass through the transparent glass.

38. Which is the reflected ray? Use the multiple choices on the figure on the right.

39. True or false: When applying the law of reflection, always measure the angles of incidence and reflection with respect to the surface that the light is striking.

40. The law of reflection states that the angle of incidence is equal to the angle of reflection ($\theta_i = \theta_r$). However, if a mirror is curved slightly outward (like the side-view mirror on a car), 
   A) $\theta_i = \theta_r$, no matter what the angle of incidence. 
   B) $\theta_i > \theta_r$, regardless of the curvature of the mirror. 
   C) $\theta_i < \theta_r$, regardless of the curvature of the mirror. 
   D) $\theta_i = \theta_r$, regardless of the curvature of the mirror.

41. A specular reflection will appear 
   A) sharp, clear, and well-focused. 
   B) blurry and poorly focused. 
   C) the opposite color of the original object.

42. Using either a mirror or a lens, a virtual image will always 
   A) appear smaller than the original object. 
   B) appear larger than the original object. 
   C) appear upside down (inverted). 
   D) appear right side up.

43. Parallel rays of light strike a convex mirror. The reflected rays 
   A) are parallel as well. They bounce back along their original path. 
   B) are everywhere. Curved mirrors can only reflect diffusely, so the rays go in all directions randomly. 
   C) converge at the focal point in front of the mirror. 
   D) diverge away from each other. The real rays will never intersect.

44. A mirror which can form only virtual images has 
   A) a concave shape. 
   B) a convex shape.

45. A mirror which can form either real or virtual images has 
   A) a concave shape. 
   B) a convex shape.

46. A mirror which is curved inward (concave shape) is a 
   A) converging mirror. 
   B) diverging mirror.

47. A lens which can form only virtual images has 
   A) a concave shape. 
   B) a convex shape.

48. A lens which can form either real or virtual images has 
   A) a concave shape. 
   B) a convex shape.

49. A lens which is curved inward (concave shape) is a 
   A) converging lens. 
   B) diverging lens.

50. How can you use a lens to form a virtual (upright), magnified image ($h_o > h_i$)? 
   A) You can’t. Lenses cannot magnify images. 
   B) Use a converging lens, and make sure that the object is far from the lens ($d_o > f$). 
   C) Use a converging lens, and make sure that the object is close to the lens ($d_o < f$). 
   D) Use a diverging lens. The $d_o$ does not matter because diverging lenses can only form magnified images.

51. As a light wave passes from glass to air, 
   A) it slows down and bends toward the normal. 
   B) it slows down and bends away from the normal. 
   C) it speeds up and bends toward the normal. 
   D) it speeds up and bends away from the normal. 
   E) it does not bend because the speed does not change.

52. In the figure shown on the right, which ray represents the refracted beam of light? Use the multiple choices labeled on the diagram.

53. Under what circumstance would light traveling from air to glass remain unrefracted (un-bent)? 
   A) Under all circumstances. The angle of incidence = the angle of refraction, and no bending occurs. 
   B) When the index of refraction of the glass exactly equals the index of refraction of the air. 
   C) If the light is traveling parallel to the normal to the surface when it strikes the boundary, it will not refract. 
   D) If the light is traveling perpendicular to the normal to the surface, it will not refract.

54. When you see a rainbow in the sky, 
   A) the colors may appear in any order at all, not just ROYGBIV. Any color might appear on top, not just red or blue-violet. It’s completely random, and this is what makes rainbows so special! 
   B) sometimes the red band is on top, sometimes the blue band is. The colors still appear in ROYGBIV order. 
   C) the colors will be in ROYGBIV order with the blue-violet on top and the red on bottom. 
   D) the colors will be in ROYGBIV order with the red on top and the blue-violet on bottom.