Your name:	
Your TA:	
Your section Day/Time:	

Multiple Choice	x	
13		
14		
15		
16		
17		
18		
19		
20		
Total	x	

PHY 101 Exam III

Wednesday, November 29, 2:15-3:35PM

Please be sure to show your work where it is requested. If no work is shown where it is requested, you will not receive any points. Partial credit will be given where appropriate, so *show me your physics thoughts.* Don't forget to include units with your quantitative answers.

Please answer the following multiple choice questions. Circle only one answer per question.

(1) Electric potential, measured in Volts, is the ratio of electric energy to amount of electric
A. voltage.
B. resistance.
C. current.
D. charge.

$\Delta U_E = q\,\Delta V$

(2) A capacitor with capacitance C has been charged with $+Q$ on one plate and Q on the other plate. Which of these statements is true?
A. The potential difference between the plates is QC.
B. The energy stored is $\frac{1}{2}Q\Delta V$.
C. The energy stored is $\frac{1}{2}Q^2C$.
D. The potential difference across the plates is $Q^2/2C$.

$U = \frac{1}{2} Q \Delta V$

(3) A bird can safely land on a bare high voltage power line because
A. Its feet are good insulators, and therefore it is protected.
B. Its internal resistance is very high, so very little current will flow.
C. If both feet are touching the bare wire, they are at the same potential, therefore no current can flow between the feet and through the birds body.
D. The line cannot deliver enough current to harm it.

(4) An Ohm is equivalent to a(n)
A. Volt/meter.
B. Coulomb/volt.
C. Ampere/Coulomb.
D. Volt/Ampere.

$\Delta V = IR$

(5) How does the resistance of a piece of conducting wire change if both its length and diameter are doubled?
A. Remains the same
B. half as much
C. two times as much
D. four times as much

$R = \rho \frac{L}{A}$ $L \to 2L$, $A \to 4A$ $R = \rho \frac{2L}{4A} = \frac{1}{2}\rho\frac{L}{A}$

(6) Four 12 Ω (Ohm) resistors are connected together. What is the least resistance that can be attained with these resistors?
A. 12 Ω
B. 6 Ω
C. 3 Ω
D. 2 Ω

in parallel

$\frac{1}{12\Omega} + \frac{1}{12\Omega} + \frac{1}{12\Omega} + \frac{1}{12\Omega} = \frac{4}{12\Omega} = \frac{1}{R_{eq}}$

$R_{eq} = 3\Omega$

(7) A straight wire is carrying a current upward. Observed from above (i.e., looking downward towards the wire), the magnetic field lines are
A. radially outward.
B. forming counter-clockwise circles.
C. radially inward.
D. forming clockwise circles.

(8) The SI unit of magnetic field is the Tesla, which is equivalent to a (start with unit analysis of Faraday's Law)
A. Newton/Coulomb.
B. Ampere/meter.
C. Joule/(Ampere meter^2).
D. Magnon.

(9) The magnetic field lines inside a bar magnet go in what direction?
A. from south pole to north pole
B. from north pole to south pole
C. from side to side
D. There are no magnetic field lines inside a bar magnet.

(10) Faraday's law of induction states that the emf/voltage induced in a rectangular loop of wire is proportional to
A. the magnetic flux.
B. the time variation of the magnetic flux.
C. current divided by the time.
D. the magnetic flux density times the area of the loop.

(11) A loop of wire is moved through a region of uniform magnetic field. As it is moved, its orientation with respect to the magnetic field direction does not change. The induced current at this time in the loop:
A. depends on the shape of the loop
B. depends on the magnitude of the field
C. depends on the speed with which it is moved
D. is zero

(12) The north end of a bar magnet is pushed downward toward a wire loop in the plane of the paper. In which direction is the induced current, and which way is the induced magnetic field?
A. clockwise, into the paper
B. clockwise, out of the paper
C. counter-clockwise, into the paper
D. counter-clockwise, out of the paper

Now respond to the following short answer questions. Please answer THREE out of FOUR for short answer questions (13)-(16). CLEARLY indicate which ones you would like to be graded on the front sheet of the exam.

(13) Describe how a DC motor works. Be sure to list the parts and describe the function for each part.

See practice final solutions

(14) Describe how it was discovered that current carrying wires generate magnetic fields. Hint: We did the demo in class. And how the strength of the magnetic field depend on distance from a long and straight current carrying wire?

There was a compass near the/a circuit. When current was pumped through the circuit, the compass needle changed orientation.

$B = \frac{\mu_0 I}{2\pi r}$ → inversely related to r

(15) Describe the two major rules used to analyze circuits. What conservation laws do they come from?

See practice Exam III

(16) Describe the jumping ring demo we did in class. What law was it demostrating? Which type of ring reached the highest in the air and why? What happened when there was a break in one of the rings? How high did it jump?

Faraday's Law, Lenz's law

The ring that was most conductive (the Nitrogen cooled aluminum) ring reached the top of Stolkin given the induced voltage and hence current that was in the ring so that it magnetized temporarily in such a way that the magnet pole of the solenoid repelled the like → magnetic pole in the ring.

The ring with the break did not jump → no current so no B.

Now answer THREE of the following FOUR quantitative questions (17)-(20). Please clearly indicate which ones you would like to be graded on the front sheet of the exam. You are welcome to approximate g as 10 m/s^2, π as 3, ϵ_0 as 9×10^{-12} $C^2/(N\,m^2)$, the mass of the electron as 9×10^{-31} kg, and the charge of the electron as -2×10^{-19} C to obtain numbers. See how close you come to reaching a number without the use of a calculator.

(17) In an electron gun, electrons are accelerated from the cathode (negatively charged plate) toward the anode (positively charged plate). The potential difference between the cathode and anode is 0.9 kV.

(a) Write down the conservation of energy for this system as the electrons travel from the cathode to the anode.

$$K_i + U_{\varepsilon i} = K_f + U_{ef}$$

$$\frac{1}{2} m_e v_i^2 + q_e V_i = \frac{1}{2} m_e V_f^2 + q_e V_f$$

(b) If we assume that the initial kinetic energy of the electrons as they leave the cathode is negligible, i.e. zero, what is the speed of the electrons as they reach the anode?

$$q_e V_i = \frac{1}{2} m_e V_f^2 + q_e V_f$$

$$q_e (V_i - V_f) = \frac{1}{2} m_e V_f^2$$

$$q_e (-\Delta V) = \frac{1}{2} m_e V_f^2$$

$$\sqrt{\frac{2(q_e(-\Delta V))}{m}} = V_f = \sqrt{\frac{2(2\times10^{-19}\,C)(900\,V)}{9\times10^{-31}\,kg}}$$

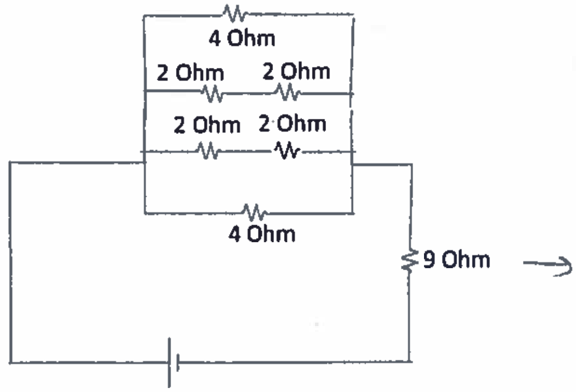
$$= \sqrt{400\times10^{12}\ \frac{m^2}{s^2}} = \sqrt{4\times10^{14}\ m^2/s^2}$$

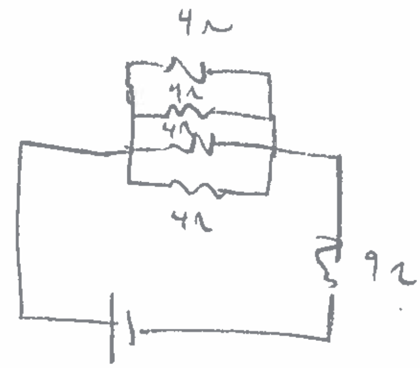
2×10^{7} m/s

$$\begin{array}{r} 2\,3\,1 \\ -1\,9 \\ \hline 1\,2 \end{array}$$

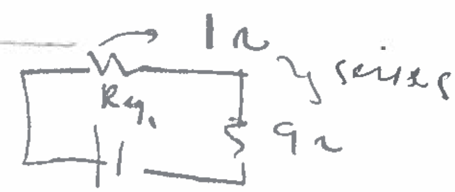
(18) Consider the circuit diagram below.

(a) Find the equivalent resistance for the circuit in which all 7 resistors in the circuit are reduced to one equivalent resistance.





$$\frac{1}{R_{eq_1}} = \frac{1}{4\Omega} + \frac{1}{4\Omega} + \frac{1}{4\Omega} + \frac{1}{4\Omega} = \frac{1}{1\Omega}$$



$$R_{eq} = 1\Omega + 9\Omega = 10\Omega$$

(b) If the battery is a 30 V battery, what is the current in the circuit?

$$\Delta V = IR$$

$$\frac{\Delta V}{R} = I = \frac{30\,V}{10\Omega} = 3 \text{ Amps}$$

(c) With this 30 V battery, what is the current through the 9 Ohm (Ω) resistor?

also 3 Amps since all of the current in the circuit goes through the 9Ω resistor.

(19) You are designing the main solenoid for an MRI machine. The solenoid should be 2 m in length. When the current is 100 A, the magnetic field strength inside should be 0.5 T. How many

→

turns should your solenoid have to achieve the magnetic field strength of 0.5 T?

Start w/ $B = \frac{\mu_0 N I}{L}$ → Isolate for N

$B = .5\,T$

$I = 100\,A$

$L = 2\,m$

$\frac{BL}{\mu_0 I} = N$

$$N = \frac{(.5\,T)(2\,m)}{(4\pi \times 10^{-7}\ \text{[illegible]})(100\,A)} = \frac{1}{4\pi \times 10^{-5}} = \frac{1}{12} \times 10^{5}$$

(20) Crocodiles are thought to be able to detect changes in the flux due to Earth's magnetic field as they move their heads. Suppose a crocodile is initially facing north. Consider a vertical, circular loop of neurons inside the crocodile's head with radius 10 cm. The strength of the Earth's magnetic field is approximately 30 μT. The loop of neurons is initially perpendicular to the direction of the Earth's magnetic field. The crocodile rotates its head 90 degrees until it is facing east in a time interval of 3 s.

(a) What is the magnetic flux Φ_B through the loop of neurons when the crocodile's head is facing north (the initial position)?

$$\Phi_{B_i} = BA\cos(\theta) = \underbrace{(30 \times 10^{-6}\,T)}_{B}\underbrace{(\pi(.1\,m)^2)}_{A}\underbrace{\cos(0^\circ)}_{=1}$$

$$= 90 \times 10^{-8}\ T\,m^2$$

$\pi \approx 3$

(b) What is the magnetic flux Φ_B through the loop of neurons when the crocodile's head is facing east (the final position)? Hint: Can any magnetic flux go through the loop axis when the crocodile's head is in this position?

since $\theta = 90^\circ$ and $\cos(90^\circ) = 0$,

then $\Phi_f = 0$

What is the induced voltage in this loop of neurons as the crocodile turns its head (from north to east)?

$$\Delta V = \left| \underset{=1}{N} \frac{\Delta \Phi_B}{\Delta t} \right| = \left| \frac{\Delta \Phi_B}{\Delta t} \right| = \left| \frac{\overset{0}{\Phi_{Bf}} - \Phi_{Bi}}{\Delta t} \right| = \frac{90 \times 10^{-8}\ T\,m^2}{3\,s}$$

$$= 30 \times 10^{-8}\ \text{Volts}$$

$$= 3 \times 10^{-7}\ \text{Volts}$$