Nagy,

Tibor

Please, keep this exam CLOSED until advised by the instructor.

60 minute long closed book exam.

Fill out the bubble sheet: last name, first initial, student number. Leave the section, code, form and signature areas empty.

A one-sided handwritten 8.5 by 11 help sheet is allowed.

When done, hand in your test and your bubble sheet.

Thank you and good luck!

Possibly useful constants:

- \( k = 8.9876 \times 10^9 \text{Nm}^2/C^2 \)
- \( \epsilon_0 = 8.8542 \times 10^{-12} \text{As/(Vm)} \)
- \( e = 1.6022 \times 10^{-19} \text{C} \)
- \( m_e = 9.1094 \times 10^{-31} \text{kg} \)
- 1 angstrom = \( 10^{-10} \text{ m} \)
- 1 fermi = \( 10^{-15} \text{ m} \)
At the fundamental, microscopic level which of the following forces are electromagnetic in nature?

1. A. air drag  
   B. normal force  
   C. buoyant force  
   D. kinetic friction  
   E. none of the forces on this list  
   F. tension force  
   G. all the forces on this list  
   H. static friction

What is the magnitude of the electric force between a proton and an electron when they are at a distance of 4.51 angstrom from each other?

\[ (in \text{ N}) \]

2. A. \(5.81 \times 10^{-10}\)  
   B. \(7.26 \times 10^{-10}\)  
   C. \(9.07 \times 10^{-10}\)  
   D. \(1.13 \times 10^{-9}\)  
   E. \(1.42 \times 10^{-9}\)  
   F. \(1.77 \times 10^{-9}\)  
   G. \(2.22 \times 10^{-9}\)  
   H. \(2.77 \times 10^{-9}\)

What is the electric potential produced by the proton at this distance from the proton?

\[ (in \text{ V}) \]

3. A. \(2.04\)  
   B. \(2.55\)  
   C. \(3.19\)  
   D. \(3.99\)  
   E. \(4.99\)  
   F. \(6.24\)  
   G. \(7.80\)  
   H. \(9.74\)

What is the potential energy of the proton-electron system when they are at this same distance from each other?

\[ (in \text{ J}) \]

4. A. \(-1.13 \times 10^{-9}\)  
   B. \(-1.02 \times 10^{-18}\)  
   C. \(-5.12 \times 10^{-19}\)  
   D. \(-2.56 \times 10^{-19}\)  
   E. \(0.00\)  
   F. \(2.56 \times 10^{-19}\)  
   G. \(5.12 \times 10^{-19}\)  
   H. \(1.02 \times 10^{-18}\)
Four point charges equal in magnitude are arranged at the corners of a square as shown in the figure.

An insulating sphere with a radius of \( R = 5.40 \text{ cm} \) carries \( 3.88 \times 10^{-9} \text{ C} \) of electric charge. The electric charge is distributed uniformly throughout the volume of the sphere.

2 pt What is the direction of the electric field at point \( a \)?

5. A Circle The electric field is zero at this point.
   B Circle To the right.
   C Circle To the left.
   D Circle Up (to the top of the page).
   E Circle Down (to the bottom of the page).

2 pt What is the direction of the electric field at point \( b \)?

6. A Circle The electric field is zero at this point.
   B Circle To the right.
   C Circle Down (to the bottom of the page).
   D Circle Up (to the top of the page).
   E Circle To the left.

2 pt Select the only true statement about the electric potential at points \( a \), \( b \) and \( c \).

7. A Circle The electric potential equals zero at points \( a \) and \( c \) but not at \( b \).
   B Circle The electric potential equals zero at points \( a \), \( b \) and \( c \).
   C Circle The electric potential equals zero at points \( a \) and \( b \) but not at \( c \).
   D Circle The electric potential equals zero at none of these points.
   E Circle The electric potential equals zero at point \( a \) but not at \( b \) or \( c \).
In the diagram below, \( C_1 = 8.45 \text{ mF} \), \( C_2 = 1.62 \text{ mF} \), and \( C_3 = 7.11 \text{ mF} \). The potential difference across \( C_2 \) is 97.0 V.

What is the potential difference between A and B? (in V)

- A\( \bigcirc \) 1.58 \( \times \) 10^2
- B\( \bigcirc \) 1.97 \( \times \) 10^2
- D\( \bigcirc \) 3.08 \( \times \) 10^2
- E\( \bigcirc \) 3.85 \( \times \) 10^2
- G\( \bigcirc \) 6.02 \( \times \) 10^2
- H\( \bigcirc \) 7.52 \( \times \) 10^2

The starter motor of a car engine draws an electric current of 130 A from the battery. The copper wire to the motor is 4.10 mm in diameter and 1.33 m long. The starter motor runs for 0.45 s before the car engine starts up. How much electric charge passes through the starter motor? (in C)

- A\( \bigcirc \) 1.92 \( \times \) 10^1
- B\( \bigcirc \) 2.40 \( \times \) 10^1
- D\( \bigcirc \) 3.74 \( \times \) 10^1
- E\( \bigcirc \) 4.68 \( \times \) 10^1
- G\( \bigcirc \) 7.31 \( \times \) 10^1
- H\( \bigcirc \) 9.14 \( \times \) 10^1

What is the current density in the wire? (in k/m^2)

- A\( \bigcirc \) 3.23 \( \times \) 10^6
- B\( \bigcirc \) 4.03 \( \times \) 10^6
- D\( \bigcirc \) 6.30 \( \times \) 10^6
- E\( \bigcirc \) 7.88 \( \times \) 10^6
- G\( \bigcirc \) 1.23 \( \times \) 10^7
- H\( \bigcirc \) 1.54 \( \times \) 10^7

How far does an electron travel along the wire while the starter motor is on? (The density of conduction electrons in copper is \( n = 8.50 \times 10^{28} \text{ 1/m}^3 \).) (in m)

- A\( \bigcirc \) 2.55 \( \times \) 10^{-4}
- B\( \bigcirc \) 2.88 \( \times \) 10^{-4}
- D\( \bigcirc \) 3.68 \( \times \) 10^{-4}
- E\( \bigcirc \) 4.16 \( \times \) 10^{-4}
- G\( \bigcirc \) 5.31 \( \times \) 10^{-4}
- H\( \bigcirc \) 6.00 \( \times \) 10^{-4}

When a voltage of 12.0 V is applied across the two ends of a cylindrical wire of length \( l \), radius \( r \) and resistivity \( \rho \), an electric current of 1.0 A is measured. Then the same voltage is applied to a second wire with length of 3\( l \), radius of 4\( r \) and resistivity of 4\( \rho \). What is the electric current measured in this second wire? (in A)

- A\( \bigcirc \) 1.14
- B\( \bigcirc \) 1.33
- C\( \bigcirc \) 1.56
- D\( \bigcirc \) 1.83
- E\( \bigcirc \) 2.14
- F\( \bigcirc \) 2.50
- G\( \bigcirc \) 2.92
- H\( \bigcirc \) 3.42
Consider the three electric circuits marked with X, Y and Z as shown in the figure. All the resistors and all the batteries are identical, and all the batteries are ideal.

2 pt Select the circuit with the smallest voltage drop across a single resistor.

17. A ○ circuit Z
B ○ circuits Y and Z, tie for smallest
C ○ circuits X, Y and Z, 3-way tie
D ○ circuit X
E ○ circuits X and Y, tie for smallest
F ○ circuits X and Z, tie for smallest
G ○ circuit Y

2 pt Select the circuit with the smallest current through a single resistor.

18. A ○ circuits Y and Z, tie for smallest
B ○ circuits X and Z, tie for smallest
C ○ circuit Z
D ○ circuits X and Y, tie for smallest
E ○ circuit X
F ○ circuits X, Y and Z, 3-way tie
G ○ circuit Y

2 pt Rank the total power dissipated by the entire circuit from lowest to highest. (Lowest first, highest last.)

19. A ○ Z, Y, X
B ○ X, Y, Z
C ○ Z, X, Y
D ○ X, Z, Y
E ○ Y, X, Z
F ○ Y, Z, X

4 pt Using a 8.0 V battery a 64.0 mF capacitor is charged up through an unknown resistor. The graph shows the voltage across the capacitor as a function of time.

What is the resistance of the resistor? Please, notice that the curve passes through at least one grid intersection point.

(in ohm)

20. A ○ $2.253 \times 10^1$
B ○ $2.636 \times 10^1$
C ○ $3.085 \times 10^1$
D ○ $3.609 \times 10^1$
E ○ $4.222 \times 10^1$
F ○ $4.940 \times 10^1$
G ○ $5.780 \times 10^1$
H ○ $6.763 \times 10^1$