# Purdue University
# PHYS 221
# EXAM I – 10/5/04

Please use a #2 pencil to fill in data for name, student ID #, and section on the computer sheet. Mark the correct answer for each problem on the same sheet. There will be no penalty for wrong answers. Please check to see that your exam has all 16 problems. All useful basic equations and constants are provided. Note that you will not need all of the equations and constants provided to do this exam.

1 If 64 coulombs flow along a wire in 4.0 seconds, what is the average current?

a) 64 A
b) 32 A
c) 16 A
d) 4.0 A
e) None of the above

By definition:

$$I = \frac{\Delta Q}{\Delta t} = \frac{64\,C}{4\,s} = 16\,A$$

(c)

2 An aluminum nail has an excess charge of +3.2μC. How many electrons must be added to the nail to make it electrically neutral?

a) $2.0 \times 10^{13}$
b) $2.0 \times 10^{19}$
c) $3.2 \times 10^{-6}$
d) $3.2 \times 10^{6}$
e) $5.0 \times 10^{-14}$

We need to add a total charge of $-3.2\mu C$

each electron carries $-1.602 \times 10^{-19}\,C$

$$\#e^- = \frac{-3.2 \times 10^{-6}\,C}{-1.602 \times 10^{-19}} = 2 \times 10^{13}\ \text{electrons}$$

(a)

3 Two equal point charges are separated by a distance d. When the separation is reduced to d/4, what happens to the force between the charges?

a) It decreases by a factor of 4.
b) It increases by a factor of 4.
c) It increases by a factor of 8.
d) It increases by a factor of 16.
e) It increases by a factor of more than 16.

$F_o = \frac{k q^2}{d^2}$

$F_{new} = \frac{k q^2}{(d/4)^2} = \frac{k q^2}{\frac{d^2}{16}} = 16 \frac{k q^2}{d^2}$

$= 16(F_o)$

[d)]

4 If a 22-Ω resistor has a current of 2.0 A flowing through it, what is the potential difference across it?

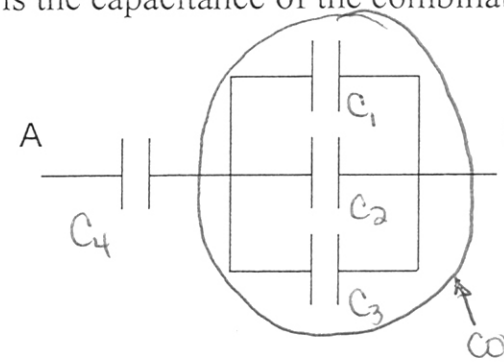
a) 0.091 V
b) 44 V
c) 11 V
d) 24 V
e) 20 V

$V = IR$

$= (2\,A)(22\,\Omega) = 44\,V$

[b)]

5 The arrangement below is composed of four 6.0-mF capacitors. What is the capacitance of the combination? (15 POINTS)

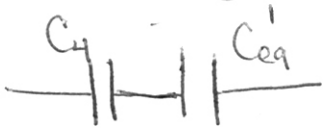



a) 24.0 mF
b) 4.5 mF
c) 8.0 mF
d) 9.0 mF
e) 12.5 mF

connected in parallel

$C'_{eq} = C_1 + C_2 + C_3 = 3(6\,mF) = 18\,mF$

Now we have two capacitors in series




$\frac{1}{C^T_{eq}} = \frac{1}{C'_{eq}} + \frac{1}{C_4} = \frac{1}{18\,mF} + \frac{1}{6\,mF}$

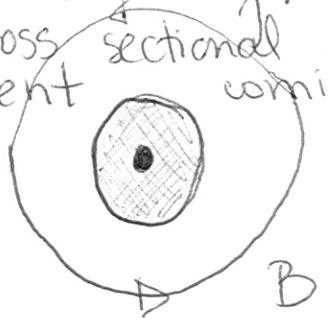
$C^T_{eq} = \frac{18\,mF}{4} = 4.5\,mF$ (b)

6 A straight wire is carrying a current upward. Observed from above (i.e., looking downward toward the wire), the magnetic field lines are


a) radially outward.
b) radially inward.
c) forming clockwise circles.
d) forming counter-clockwise circles.
e) directed toward the observer.

Observed from above we see the cross sectional area of the wire and a current coming towards us.

Use RHR-2



7 A power line carries 1000 A at a height of 20 m above the ground. What is the resulting magnetic field at ground level? (15 POINTS)

a) 50 mT
b) 0.13 mT
c) 13 μT
d) 10 μT
e) 5.0 μT

$$B = \frac{\mu_0 I}{2\pi r}$$

$$B = \frac{(4\pi \times 10^{-7}\ T\cdot m/A)(1000\ A)}{2\pi (20\ m)}$$

$$B = 1 \times 10^{-5}\ T = \boxed{10\ \mu T}$$

$$\boxed{d)}$$

8 The potential differences around a loop ABCA in a circuit (starting at A and going back to A) are $V_{AB}$=10 V, $V_{BC}$=6 V, and $V_{CA}$. What is $V_{CA}$?

a) 16 V
b) 4 V
c) -4 V
d) -16 V
e) -12 V

According to Kirchhoff's loop rule

$$V_{AB} + V_{BC} + V_{CA} = 0$$

$$V_{CA} = -V_{AB} - V_{BC}$$

$$= -(10\ V) - (6\ V) = \boxed{-16\ V}$$

$$\boxed{d)}$$

9 An air-filled parallel plate capacitor is attached to a voltage source and charged. The voltage source is removed, and then the plates are separated to double their previous distance. What happens to the electric field between the plates when they are separated?

a) It doubles.
b) It quadruples.
c) It halves.
d) It is diminished by a factor of 4.
e) It stays the same.

Since the charge remains constant the E field stays the same.

e)

10 A parallel plate capacitor has a paper dielectric having dielectric strength 8.0 kV/mm and dielectric constant 3.0. The plate area is 3000 $cm^2$ and the plate separation is 0.50 mm. What is the capacitance? (15 POINTS)

a) 16 nF
b) 4.2 nF
c) 5.3 nF
d) 1.6 nF
e) 4.2 pF

$\kappa$ dielectric constant.

$$C = \frac{\kappa \varepsilon_0 A}{d}$$

$$A = 3000\,cm^2 \times \left(\frac{1\,m}{100\,cm}\right)^2$$

$$A = 0.3\,m^2$$

$$C = \frac{(3)\left(8.854 \times 10^{-12}\,\frac{C^2}{N \cdot m^2}\right)(0.3\,m^2)}{(0.5 \times 10^{-3}\,m)}$$

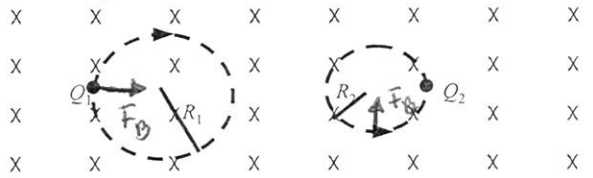
$$C = 15.9\,nF$$

a)

11 Two charged particles are traveling in circular orbits with the same speed in a region of uniform magnetic field that is directed into the page, as shown. The magnitude of the charge on each particle is identical, but the signs of the charges are unequal.

$qvB = \frac{mv^2}{r}$

$r = \left(\frac{v}{qB}\right) m$ ($v$ constant)




since $R_1 > R_2$ and the radius is proportional to the mass

$m_1 > m_2$

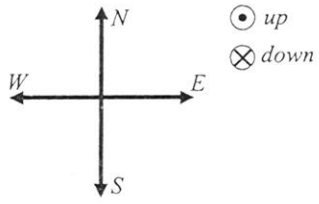
Which one of the entries in the table below is correct?

| | *Mass Relationship* | *Sign of charge $Q_1$* | *Sign of charge $Q_2$* |
|---|---|---|---|
| a) | $m_1 = m_2$ | + | − |
| b) | $m_1 > m_2$ | − | + |
| c) | $m_1 < m_2$ | − | + |
| d) | $m_1 > m_2$ | + | − |
| e) | $m_1 < m_2$ | + | − |

For $Q_1$ the magnetic force is point towards the center of the orbit, it has to be negative.

For $Q_2$ the magnetic force is pointing towards the center of the orbit, it has to be positive. **b)**

12 A negative ion is moving east near the equator where the Earth's magnetic field is horizontal to the north. The direction of the magnetic force on the ion is

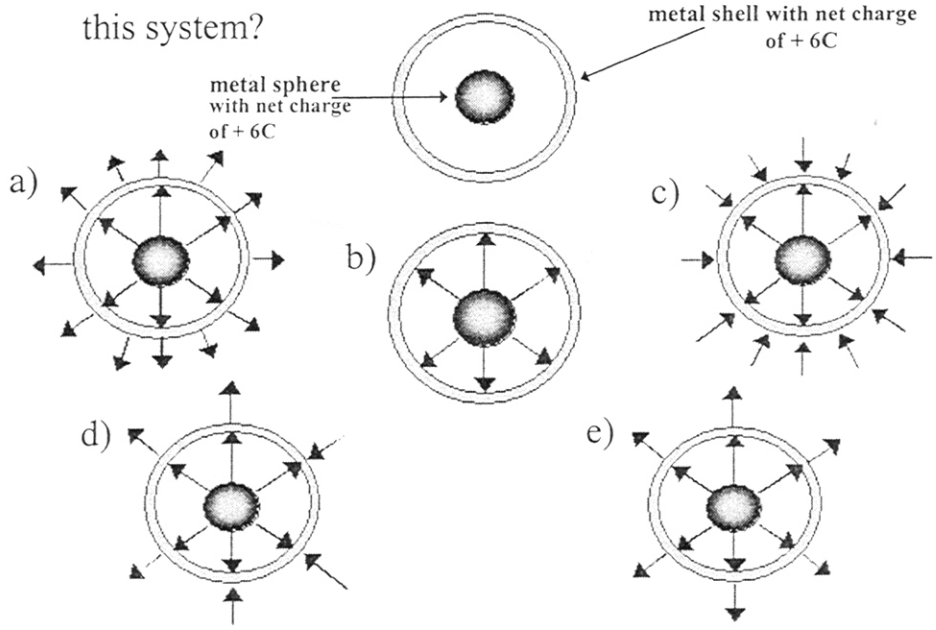



a) north.
b) south.
c) up.
d) down.
e) not meaningful since the force is zero.


Following RHR-1 the magnetic force on the ion is "down".

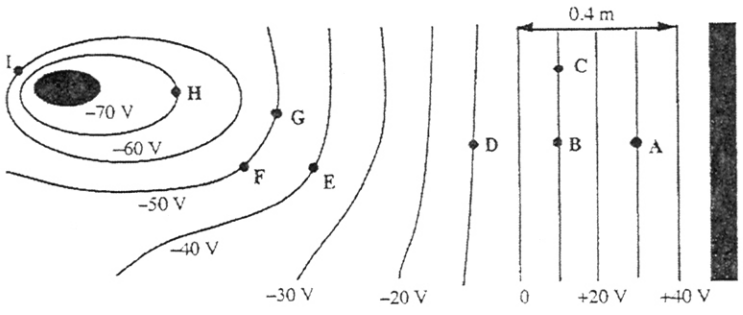
**d)**

13 Which one of the following figures shows a qualitatively accurate sketch of the electric field lines in and around this system?




The number of electric field lines is proportional to the Electric field. [a)]

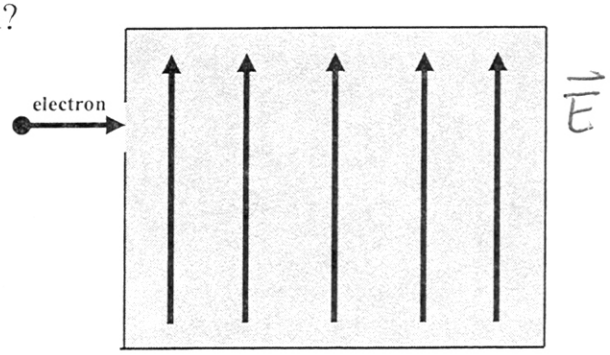
14 The sketch below shows cross sections of equipotential surfaces between two charged conductors that are shown in solid black. Various points on the equipotential surfaces near the conductors are labeled A, B, C, …, I. What is the potential difference between points F and G?




a) 0 V
b) 10 V
c) 20 V
d) 30 V
e) 40 V

0 V, Both points are on the same equipotential surface. [a)]

15 An electron traveling horizontally enters a region where a uniform electric field is directed upward. What is the direction of the force exerted on the electron once it has entered the field?




a) to the left
b) to the right
c) upward
d) downward
e) out of the page, toward the reader

Since it's an electron the electric force would be downward [d]

16 A resistor has a resistance of 30 Ω at 20 °C. If the temperature coefficient is $4.5 \times 10^{-3}\ °C^{-1}$, what is the resistance at 200 °C? (15 POINTS)

a) 24 Ω
b) 27 Ω
c) 48 Ω
d) 54 Ω
e) 57 Ω

$R = R_o(1 + \alpha(T_c - 20°C))$

$\alpha = 4.5 \times 10^{-3}\ °C^{-1}$

$R_o = 30\ \Omega$

$T_c = 200°C$

$R = 30[1 + (4.5 \times 10^{-3}\ °C^{-1})(200°C - 20°C)]$

$R = 54.3\ \Omega$ d)