THE
Final Exam

Physics 204

Fall 2017

Profs. Wu, Martens Yaverbaum
John Jay College of Criminal Justice
the City University of New York

FIELDS.

THE COMPASS CHRONICLE

ILLUSTRATED LIGHT-PARSECIAL PAPER OF NEWS

7102 E.E. AUGUST 3 Price 6d

**Funding in Fumes:
It's the End of the Line for Data Rails**

•They say burn the message, not the messenger. Sage advice when the news is bad. This week, however, the message is exciting and the messenger is - at least during the day - already plenty hot on his own.

•The planet Mercury has just returned to the night sky. For

The planet Mercury has just returned to the night sky. For months, it has been visible at dawn only. Now, having completed its most recent crossing from the right to the left side of the sun, Mercury can be observed in the low south-west sky at twilight (these

On Thursday Jan. 10, for example, look up just as it gets dark. You will find an

SOME USEFUL RELATIONS:

1) $\oint \vec{E} \cdot \overrightarrow{da} = \frac{q_{(enc)}}{\varepsilon_0}$.

2) $\oint \vec{B} \cdot \overrightarrow{da} = 0$.

3) $\oint \vec{E} \cdot \overrightarrow{dl} = -\frac{d}{dt}\int \vec{B} \cdot \overrightarrow{da}$.

4) $\oint \vec{B} \cdot \overrightarrow{dl} = \mu_0 I_{(enc)} + \mu_0 \varepsilon_0 \frac{d}{dt}\int \vec{E} \cdot \overrightarrow{da}$.

5) $\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r^2}\hat{r}$.

6) $\vec{F}_E \equiv q\vec{E}$.

7) $\vec{B} = \frac{\mu_0}{4\pi}\frac{q}{r^2}\vec{v} \times \hat{r}$.

8) $\vec{F}_B \equiv q\vec{v} \times \vec{B} = \vec{I}l \times \vec{B}$.

9) $V_a - V_b \equiv \int_a^b \vec{E} \cdot \overrightarrow{dr}$.

10) $C \equiv \frac{Q}{\Delta V}$. (Note: This "C" is capital.)

11) $I \equiv \frac{dq}{dt}$

12) $I = \frac{\Delta V}{R}$.

13) $\mathcal{E} - IR - \frac{Q}{C} = 0$. (Capital "C".)

14) $c \approx 3\ x\ 10^8\ m/s$.

15) $n\ \equiv\ \frac{c}{v}$. (Lower-case "c".)

16) $n_1 \sin\theta_1 = n_2 \sin\theta_2$.

17) $\frac{Yd}{L} = \frac{n\lambda}{2}$

18) $sin^2\theta + \ cos^2\theta = 1.$

19) $\bar{v} \equiv \frac{\Delta x}{\Delta t}.$

20) $\sum \vec{F} = m\vec{a}.$

21) $F = -Kx.$

22) $x = Acos(\omega t + \phi).$

23) $\omega = 2\pi f.$

24) $f = \frac{1}{T}.$

25) $KE = \frac{1}{2}mv^2$

26) $PE_{elastic} = \frac{1}{2}Kx^2$

27) $v = \lambda f.$

28) $v = \sqrt{\frac{T}{\mu}}.$

29) $\frac{\partial^2 y}{\partial t^2} = (v^2)\frac{\partial^2 y}{\partial x^2}.$

30) $\epsilon_0 \approx 8.85 \ x \ 10^{-12} \ \frac{C^2}{Nm^2}.$

31) $\mu_0 \approx 1.26 \times 10^{-7} \ \frac{N}{A^2}.$

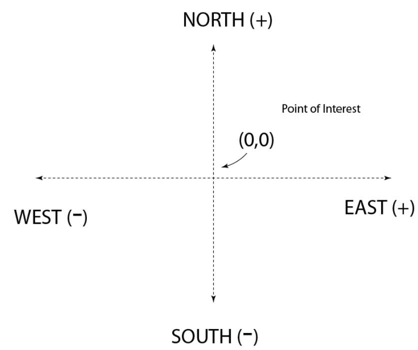
32) $m_e \approx 9.11 \ x \ 10^{-31}$ kg.

33) $m_{(NEUTRON)} \approx 1.67 \ x \ 10^{-27}$ kg

34) $q_e \approx 1.60 \ x \ 10^{-19} \ C.$

I. E-FIELDS FROM *POINT CHARGES* (25 PTS).

Two ***point-charges*** of differing magnitudes are held stationary in an enormously spacious x-y plane.



The strengths and locations of the charges are organized into a table, below.
A researcher places an instrument called a 'field detector' at the point **(0,0)**.
The detector is designed to measure electrostatic field magnitudes and directions.

Name	Charge	x-Coordinate	y-Coordinate	Ordered Pair
Q1	5	5	0	(5,0)
Q2	-2	10	0	(10,0)

Location of Interest: (0,0)

Note: All coordinates are measured and given in **meters**;
the (very very large) charge magnitudes
are given in **Coulombs**.

Also Note: The Coulomb constant for electrostatic interaction
can be very reasonably approximated by this value:

$$K_e \approx 9 \times 10^9 \frac{Nm^2}{C^2}$$

Draw a neat and clear sketch of the situation, as you understand it.
Your sketch must express a clear decision as to which direction will be designated positive and which direction will be negative (5 pts).

- Compute the Electric Field as measured at the *Point of Interest* : (0,0). That is:

  i. In Newtons/Coulomb, determine the ***magnitude*** of the ('total') ***electrostatic field*** at this location of interest (3 pts).

  ii. Express the **direction** of the ***electrostatic field*** at this *Point of Interest* (0,0).

- Now, suppose that at some given instant, we notice a PAIR OF ELECTRONS held stationary at the *Point of Interest*: (0,0). At a moment we will call ***t = 0***, the electron is released from rest at that location.

  iii. Find

    a. the magnitude and
    b. the direction
    c. of the electron's immediate instantaneous acceleration, upon finding itself in the electrostatic field described above.

Compute the Electric Field as measured at the *Point of Interest* : (0,0).

That is:

i. In Newtons/Coulomb, determine the ***magnitude*** of the ('total') ***electrostatic field*** at this location of interest.

ii. Express the **direction** of the field at this point:
of the ***electrostatic field*** at this *Point of Interest* (0,0).

Now, suppose that at some given instant,
we notice ONE ELECTRON held stationary
at the *Point of Interest*: (0,0).
At a moment we will call $\boldsymbol{t = 0}$,
the electron is released from rest at that location.

iii. Find (a) the magnitude

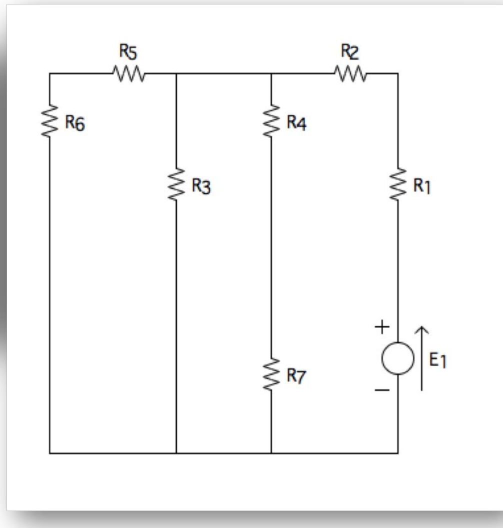
and

(b) the direction

of the electron's immediate instantaneous acceleration,
upon finding itself in the electrostatic field described above.

II. An actual CIRCUIT (25 pts).

Examine the following circuit (values provided directly to its right).



R1	100	Ω
R2	200	Ω
R3	1.00	Ω
R4	200	Ω
R5	1.00	Ω
R6	200	Ω
R7	1.00	Ω
E1	15.0	V

SHOWING ALL WORK, Determine:

a) The ***current*** flowing through each and every RESISTOR.

i. ***I*** (R1) =

ii. ***I*** (R2) =

iii. ***I*** (R3) =

iv. ***I*** (R4) =

v. ***I***(R5) =

vi. ***I***(R6) =

vii. ***I***(R7) =

i.

i. $\Delta V(R_1)$

ii. $\Delta V(R_2)$

iii. $\Delta V(R_3)$

iv. $\Delta V(R_3)$

... etc.

III THE B-FIELD DIRECTION (25 pts total)

Let:

$$\vec{A} \equiv -\hat{x} + \hat{y} - \hat{z}$$
$$B \equiv 10$$
$$\vec{C} \equiv 5\hat{x} - 5\hat{z}$$

A. Find $(\vec{C} \cdot \vec{A})$

B. Find $(\vec{A} \times \vec{C}) \cdot \vec{C}$

C. Find $c(\vec{\mathbf{A}} \times \vec{\mathbf{B}})$

Let the magnetic field produced by an infinitesimal amount of current be given by the Biot-Savart Law:

$$d\vec{\mathbf{B}} = \frac{\mu_0}{4\pi}\frac{I\vec{dl}}{r^2} \times \hat{r}$$

and

Let the magnetic force exerted on a correspondingly small amount of current by the magnetic field (produced in the manner described above) be

$$\vec{\mathbf{F}}_B = I\vec{dl} \times \vec{\mathbf{B}}$$

and let:

The direction of the vector produced by the 'cross' multiplication of two vectors, If not otherwise adjudicated, be indicated by

The 'Right-Hand' Rule.

Then:

D) A current flows with a straight wire.
The current flows toward the North.
It causes a magnetic field.
You look at a location above the wire.
At that location, in which direction does this magnetic field point?

E) A different straight wire contains current flowing toward the South.
This wire is placed into a magnetic field pointing to the left.
Other than the field, the wire is shielded from all other influences.
In which direction will this wire accelerate?

A metal rod faces North/South on two metal rails that run East/West. There is a resistor running North/South and clamped down to complete a metal rectangle. Some sort of mechanical force is applied to the metal rod so that it is pulled Eastward along the rails and thereby progressively expands the area of the rectangle. The whole apparatus is submerged in a constant magnetic field which points up toward the ceiling.

F) In what direction will positive charges in the rod be forced to move?

G) In what direction will current necessarily begin to flow? (clockwise? counterclockwise?)

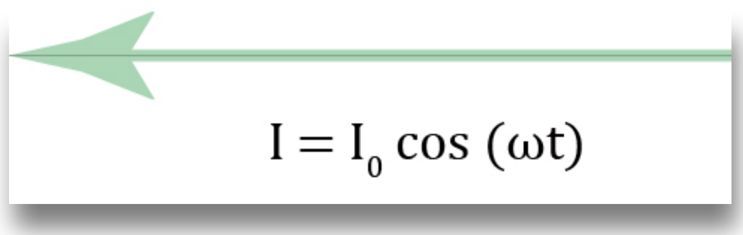
IV. Electromagnetic Radiation (25 pts).

You set up a straight line of electrical current in the lab.

The direction of this current is from right to left;

The magnitude of this current oscillates in time – getting larger and smaller in a smooth predictable familiar way.

The current flows in the manner depicted below.



According to a certain law of physics, a straight line of current automatically creates a field of a certain specific kind.

In regions near the straight current, the lines representing this field will necessarily be of a certain shape and direction.

a. CURRENT > FIELD

According to which law does current create field?

The law is one of five depicted below.

i. From the choices below, choose the letter corresponding to the correct law.

What is the name of this law?

ii. From the choices below, Choose the letter corresponding to the correct name.

Essentially what shape and direction will resemble this field?

iii. Choose the letter corresponding to the correct diagram from the choices below.

b. CHANGING FIELD > INDUCED FIELD

According to the facts of this problem, the magnitude of the current changes in time.
Therefore, the field it creates must be changing in time.

According to the physics law often credited for the industrial revolution,
Any magnetic field which changes through an area *induces* a new field throughout the perimeter of that area.

i. Pick the law which best resembles this induced field (write down the letter).

ii. Pick the name of this law.

ii. Pick the best picture to capture this induced field.

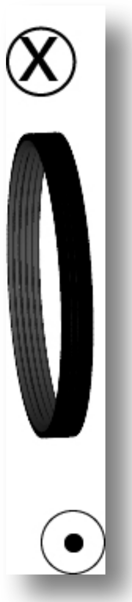
c. Repeat what you just did in (b) – to capture what the laws of nature will next do.

d. Repeat again.

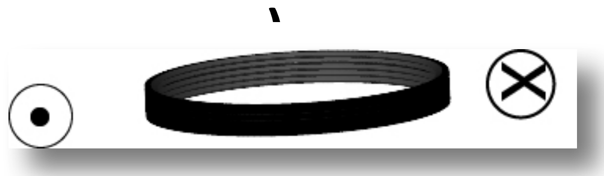
e. Draw one picture putting the four stages together.

i. Pick the equation best describes this phenomenon.
ii. At what speed does it travel?

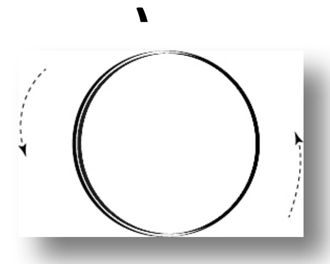
A)



B)



C)



AAA) Ampere's Law
BBB) Gauss's Law for Magnetostatics
CCC) Gauss's Law for Electrostatics
DDD) Faraday's Law
EEE) The wave equation for magnetic field

CC)

$$\frac{\partial^2 \vec{B}}{dt^2} = \frac{1}{\mu_0 \varepsilon_0} \vec{\nabla}^2 \vec{B}$$

BB)

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J} + \mu_0 \varepsilon_0 \frac{\partial \vec{E}}{\partial t}$$

AA)

$$\vec{\nabla} \cdot \vec{E} = \frac{\rho}{\varepsilon_0}$$

DD)

$$\vec{\nabla} \cdot \vec{B} = 0$$

EE)

$$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$