PHYS 2020: Practice Exam 3, Version A, April 14, '16. 7:30-9:15 PM

Your Name (please print neatly!) ___________________________

Student ID # ____

TA's name (**Circle one!!**)

Robert Ariniello	Nicholas Kellaris	Prasanth Prahladan
Thomas Gray	Andrew Spott	Shane Rightley

Day your lab meets (**Circle one!!**) Tue Wed Thu

Time your lab starts (**Circle one!!**) 8 10 12 2 4

Please follow these instructions before you start the exam!

☐ Fill in the lines above, and *circle* your TA + the day and time of your lab.

☐ Write in ***and*** *bubble in* your name *and* your ID # on the bubble sheet!

☐ Write ***and*** *bubble* the exam version **(A)** in the space (top left of the bubble sheet.)

Double check all of the above! Then, please wait until a TA announces you may begin.

There are 25 **multiple choice questions**

Please BUBBLE IN your answer on the bubble sheet. Answers circled on this exam will NOT be used for grading purposes!! Use a #2 pencil. Erase mistakes carefully.
If you can't thoroughly erase, ask for a fresh bubble sheet.
At the end, *check* that you have bubbled in *one* answer only, for all questions.

All questions are weighted the same (so don't let yourself get "stuck" on one problem, move on, come back if you have time!)

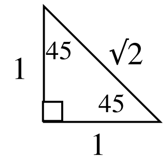
PLEASE turn in your exam in the **proper pile** up front! Ask if it's confusing - thanks!

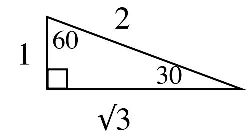
"On my honor, as a University of Colorado at Boulder student, I have neither given nor received unauthorized assistance on this work"

Signature ____

This exam is double sided, please look at the backs of pages!

Useful constants:





k = $9\text{x}10^9$ N m^2/C^2, $\mu_0 = 4\,\pi\,\text{x}10^{-7}$ T m/A
e = $1.6\text{x}10^{-19}$ C, c = $3\text{x}10^8$ m/s

On this exam, neglect gravitational forces unless we explicitly say otherwise.

Some Units:
Units of [force] = [N] = [kg*m/s^2],
Units of [energy or work] = [J] = [N*m] = [kg*m^2/s^2], [Power] = [J/s], Intensity = [J/(s*m^2)]
Units are Current = C/s, Units of resistance is Ω=Ohm=[J s/C^2] Unit of resistivity is [Ω*m]
Units of Magnetic field = [T] = [N/(C*m/s)] = [kg/(C*s)]

Useful Formulas:
Newton's 2nd Law: $\vec{F}_{net} = m\vec{a}$, Work = $\mathbf{F}\cdot\mathbf{d}$ = |F||d| cosθ, Power = $\vec{\boldsymbol{F}}\cdot\vec{\boldsymbol{v}} = |F||v|cos\theta$
Coulomb's Law: $|F_{elec}| = \frac{k|q_1||q_2|}{r^2}$

Electric Fields:
$\vec{E} = \vec{F}/q$. Special cases of the above: $\left|E_{near\ a\ point\ charge}\right| = \frac{k|q|}{r^2}$

Electric Potential (or "Voltage")
$\Delta V = \frac{\Delta PE}{q}$. Special cases of the above: $V_{near\ a\ point\ charge\ q} = \frac{kq}{r}$
For uniform fields (or short distances), $\left|\vec{E}\right| = \left|\frac{\Delta V}{\Delta d}\right|$

Capacitors:
$Q = C\Delta V,\ C_{parallel\ plate} = \frac{A}{4\pi k\ d},\ \ |E|_{parallel\ plate} = \frac{4\pi kQ}{A}$,
Stored energy in capacitor: $U = \frac{1}{2}C(\Delta V)^2 = \frac{1}{2}\frac{Q^2}{C} = \frac{1}{2}Q\Delta V$

Currents and circuits
Current is charge passing per second. Resistance is $R = \rho L/A$, where ρ = resistivity
$\Delta V = IR$ across a resistor, and power dissipated is $P = I\Delta V = I^2R = \Delta V^2/R$
Resistors in series add up, resistors in parallel obey $\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$

Magnetic fields
Force on a wire in a B-field: $F = I * length * B * \sin\theta$, direction given by a "right hand rule"
Force on a moving charge in a magnetic field is $F = q\ v\ B\sin\theta$ (again, "right hand rule")
Special case: $|B_{near\ wire}| = \frac{\mu_0}{2\pi}\frac{I}{r}$. In uniform B-field, charges move in circles, with $R = \frac{mv}{qB}$.

Faraday's law
$EMF = -N\frac{\Delta\Phi_{mag}}{\Delta t}, where\ \Phi_{mag} = BAcos\theta$, and N is the number of turns (or coils)
(Lenz' law is the minus sign in the above equation!)

Electromagnetic Waves (radiation)
For any wave with speed v, λf = v, and speed of light in vacuum = c = 3E8 m/s,
Frequency f = 1/period, [f] = [Hz = cycles/sec]

MULTIPLE CHOICE: All answers *must* be bubbled in on your bubble sheet.

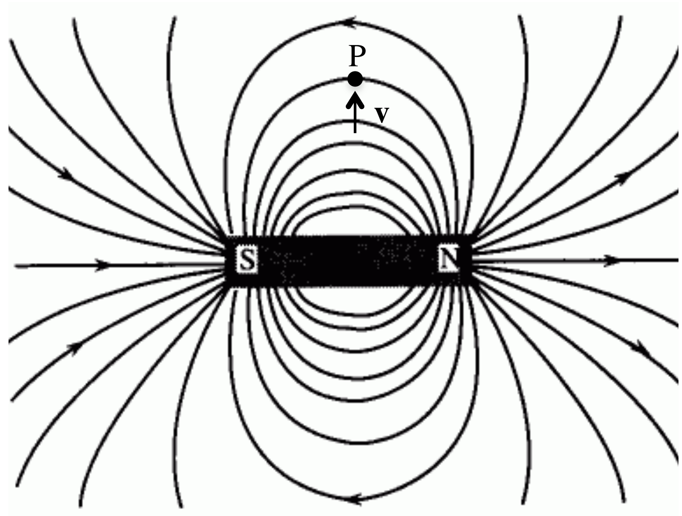
PLEASE IGNORE EARTH'S GRAVITY AND THE EARTH'S MAGNETIC FIELD IN ALL QUESTIONS (unless explicitly stated otherwise)

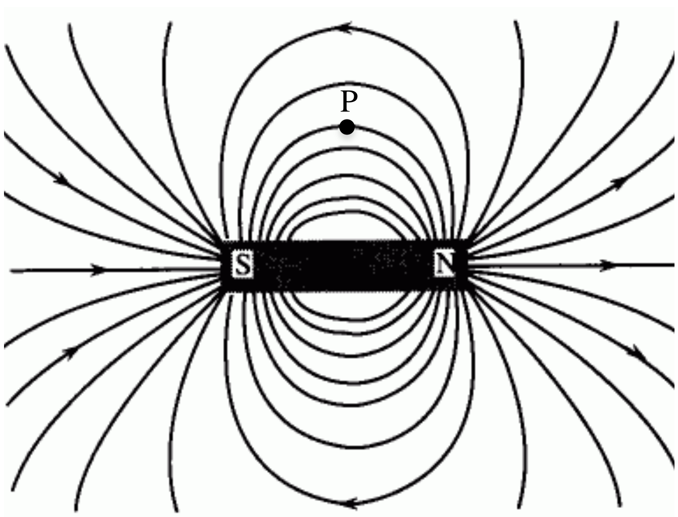
The next **two** questions are about the figure below showing a *magnetic field pattern in a region*.

1. An ELECTRON (with negative charge!) is "injected" into the figure.
It passes through point P with velocity v heading straight up the page (in the plane of the page).

What direction will it be accelerating at the instant it passes through point P?

A) Out of the page
B) Into the page
C) To the right
D) To the left
E) NONE of these is correct!





2. A proton is placed at rest at point P. What will its subsequent motion look like?
A) It will follow *exactly* the B field line it started on, heading towards the North pole, until it strikes the north pole.
B) It will follow *exactly* the B field line it started on, heading towards the South pole, until it strikes the south pole.
C) It will remain at rest.
D) It will initially follow the B field line, heading roughly towards the North pole, but will quickly start to diverge from that field line, and follow a complicated path.
E) It will initially follow the B field line, heading roughly towards the South pole, but will quickly start to diverge from that field line, and follow a complicated path.

3. You are designing a step up transformer. You would like to transform the wall voltage (120 V AC) into a secondary voltage of 12,000 V, enough to make some dangerous "lightning sparks". You have wrapped Np=100 windings on the primary, and 1 Amp will flow from the wall into the primary.

How many windings (N_s) do you need on the secondary, and what secondary current (I_s) will you get coming out?

A) $N_s = 1$; $I_s = 100$ A

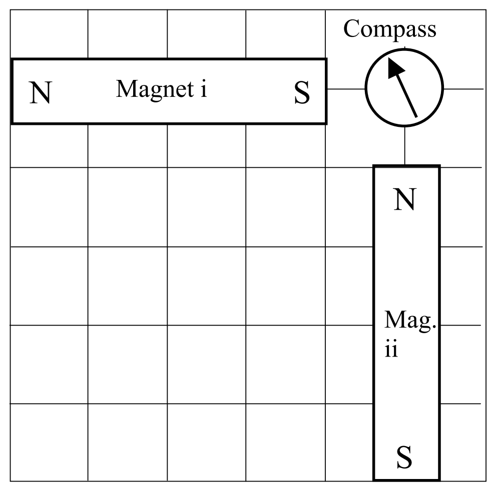
B) $N_s = 1$; $I_s = .01$ A

C) $N_s = 10{,}000$; $I_s = 100$ A

D) $N_s = 10{,}000$; $I_s = .01$ A

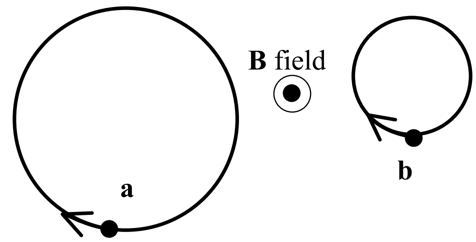
E) None of the above combinations is correct!

4. You have two magnets (labeled i and ii in the figure). They look the same, but you suspect one might be stronger. You set them on the table, and place a compass needle at the point shown (equidistant from the ends of the magnets).
The North end of the compass needle makes an angle of 30 degrees from "straight up the page", as shown.
What do you conclude?



A) Magnet **i** is stronger than Magnet **ii**
B) Magnet **ii** is stronger than Magnet **i**
C) Magnets **i** and **ii** are equal in strength
D) The figure is impossible, there is no way the compass needle would point in the direction shown no matter what the strengths of the two magnets.
D) This little experiment does not give us enough information to determine the relative strengths of the magnets

5. Two charged particles (a and b) are orbiting in a uniform magnetic field (which is pointing out the page) in the sense shown. The magnitudes of the charges are the same.



Which one of the following statements is true?

A) Both particles are negative and momentum(a) > momentum(b).

B) Both particles are positive and momentum(a) > momentum(b)

C) Both particles are negative and momentum(b) > momentum(a).

D) Both particles are positive and momentum(b) > momentum(a).

E) None of the above, or impossible to tell with the information given

6. As a beam of laser light is tuned from blue to red, the frequency f of the wave decreases. Which of the following statements is true about the electromagnetic wave?

i) The speed of the wave decreases

ii) The wavelength of the wave decreases

A) Both i and ii are true

B) Both i and ii are false

C) i is false, and ii is true

D) i is true, and ii is false

For the next two problems, there is a uniform magnetic field which points INTO the page *everywhere!* (In Fig. I, the rod slides up the page. In Fig. II, the rod slides down the page)

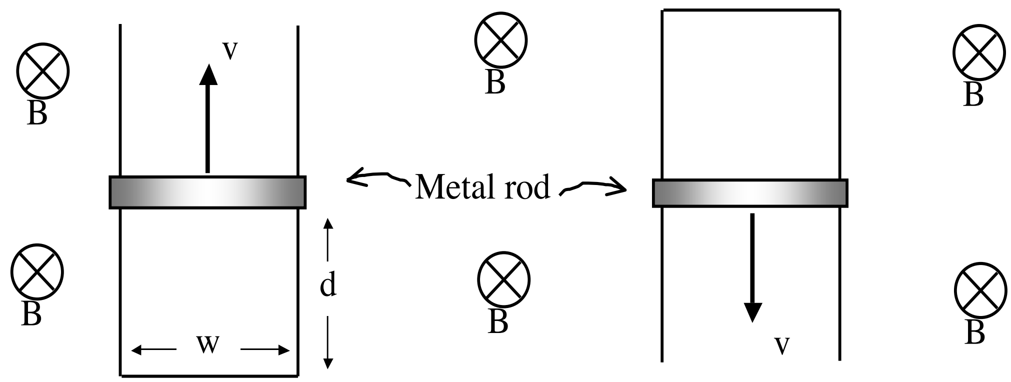


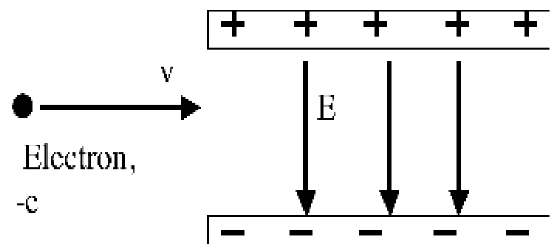
Figure I　　　　　　　　Figure II

7. In Fig. I above, suppose v=10 m/s, B=2 T, the width of the metal rod is w=3.0 m, and the rod is a distance d=5.0 m from the end of the track, as shown. The resistance of the *track* is negligible, the resistance of the *rod* is R=4Ω .
What is the magnitude of the resulting current flowing in the rod? (Careful: **current**, *not* EMF)

A) 20 A
B) 75 A
C) 25 A
D) 100 A
E) 15 A

8. In which figures above, if any, is the induced current in the rod towards the RIGHT? →
A) *Both* figures
B) *Neither* figure
C) Figure II *only*
D) Figure I *only*

9. Electrons are sent in with an initial velocity to the right through a region where there is a uniform electric field, **E** (shown) *and* a uniform magnetic field **B** (not shown). *For this problem ignore gravity*.



If you want these electrons to travel straight through (undeflected), which direction should the magnetic *field*, **B**, point?

A) To the right (i.e. the same way the electrons travel).

B) Into the page.

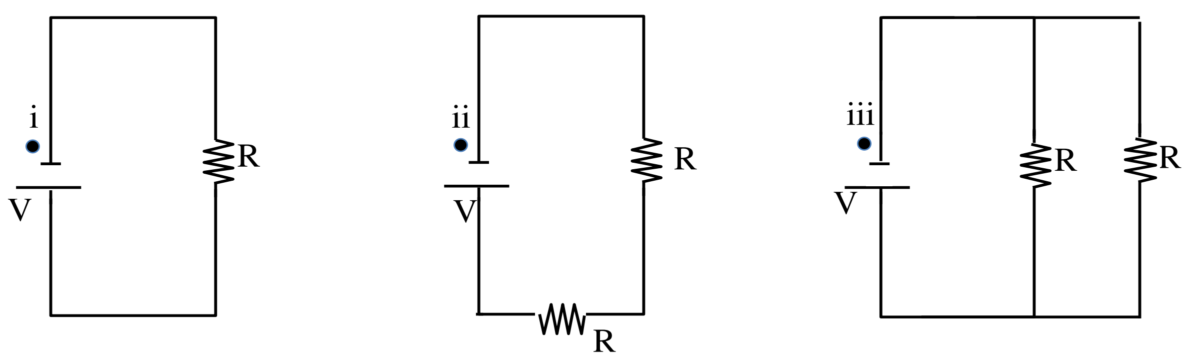
C) Out of the page.

D) Down the page (i.e. the same way the E field points).

E) Up the page (opposite the E field).

10. We have 3 circuits with ideal and identical batteries, bulbs, and wires, as shown. Magnetic field detectors are placed at the points labeled i, ii, and iii, all the same (very small!) distance from the nearby wire. The loops are large, so the other wire segments are very far away.

Rank order the STRENGTH of the measured magnetic field at those three points, from largest to smallest.



A) $B_i > B_{ii} > B_{iii}$.

B) $B_{iii} > B_i > B_{ii}$.

C) $B_i = B_{ii} > B_{iii}$.

D) $B_i = B_{iii} > B_{ii}$.

E) $B_i = B_{ii} = B_{iii}$.

11. A single small conducting loop (area 2 m^2) lies flat on the table.
There is a strong magnetic field B = 5.0 T initially pointing down (normal to the table top).
Over the course of 0.10 sec, the field is changed continuously to B = 3.0 T pointing up.

What is the magnitude of the average induced emf in the coil?

A) 160 V
B) 20 V
C) 80 V
D) 40 V
E) None of these is correct!

12. At a fixed moment in time, the strength of the electric field in a radio wave at various values of x is shown. What is the frequency of this wave?

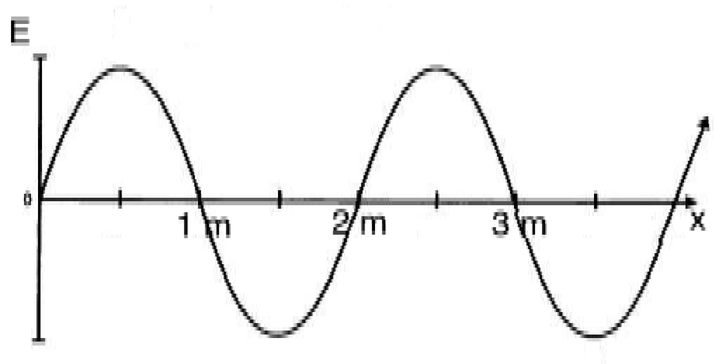
A) 6.7E7 Hz

B) 3E8 Hz

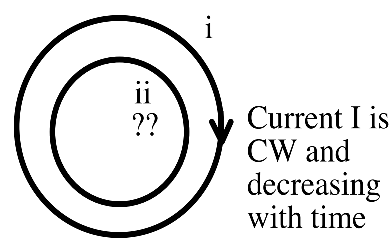
C) 2E-8 Hz

D) 6.7E-9 Hz

E) 1.5E8 Hz

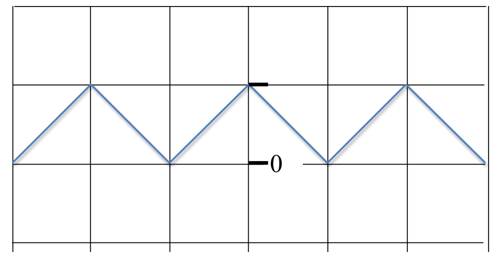


13. Similar to an experiment we did in lab, we have an outer loop of wire (labeled i) sitting in the plane of the page, with a smaller inner loop (labeled ii), also in the plane of the page, sitting inside the first. The loops are not directly connected in any way.
If the current around loop i flows CLOCKWISE (CW) and is steadily DECREASING with time,
what is the induced current in the smaller loop ii doing?

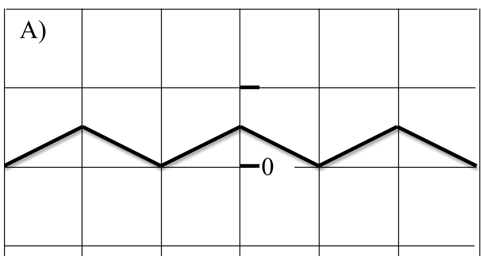


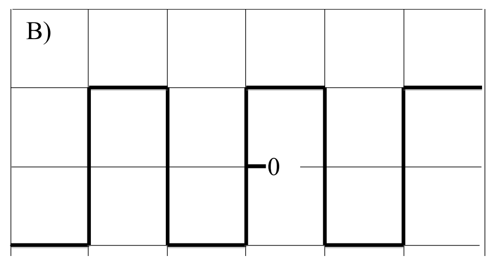
A) There is no induced current in the inner loop in this situation
B) It flows clockwise too.
C) It flows counter-clockwise
D) There is not enough information to decide.

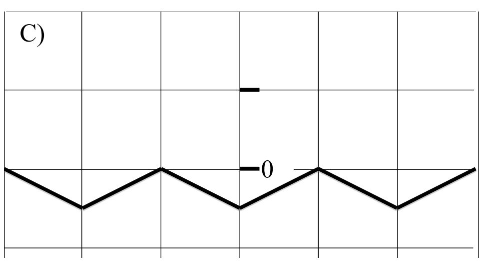
14. In the lab, we had a current source that could produce a "triangle wave" of current through loop i. This means the current through loop i (as a function of time), looks like the figure to the right: the current "ramps up", then "ramps down", over and over.

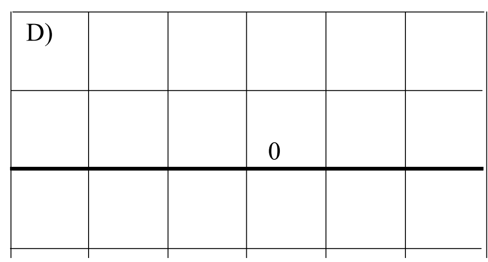


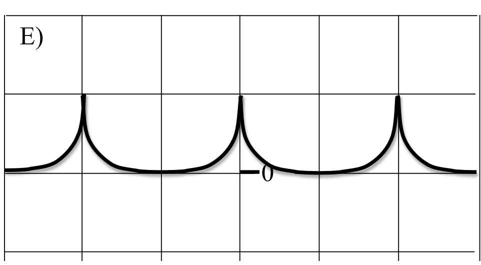
What shape would you expect to see if you looked at the induced current in loop ii (the inner loop) as a function of time? Choose the figure which seems closest to what you should expect.











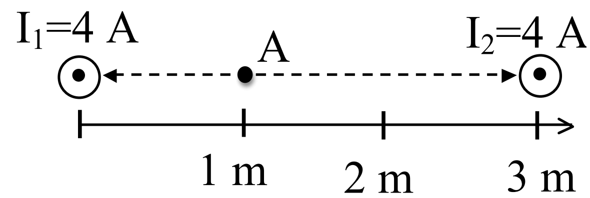
NOTE: We don't have long answer questions on our exams, but here are some older ones from years ago – the physics could easily be turned into Multi-choice, so it's worth study!

LONG ANSWER QUESTIONS. There are 2 problems, each with several parts. Please write in the space provided. (If you need more room, use a spare sheet, and indicate clearly in the space provided that you did!) In ALL problems, show and explain your work <u>briefly but clearly</u>.

<u>Problem 1:</u>

i) Two long parallel current-carrying wires, labeled I_1, I_2, carry <u>equal</u> currents of 4 Amps, perpendicular to (out of) the plane of the page. I_1 is at the origin, I_2 is 3 meters to the right.

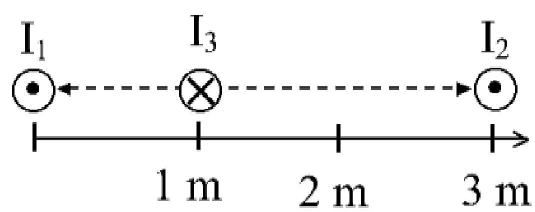
The point A is shown one third of the way between the two wires. (There is no object at point A, it is just a point in empty space.)



What is the net magnetic *<u>field</u>* at point A?

Please clearly indicate the direction, and the magnitude of your answer, with units. Explain your reasoning in the space below. *(6 pts)*

ii) Without changing I_1 or I_2, we introduce a third long wire, labeled I_3, at the location (A) considered above, carrying current INTO the plane of the page.



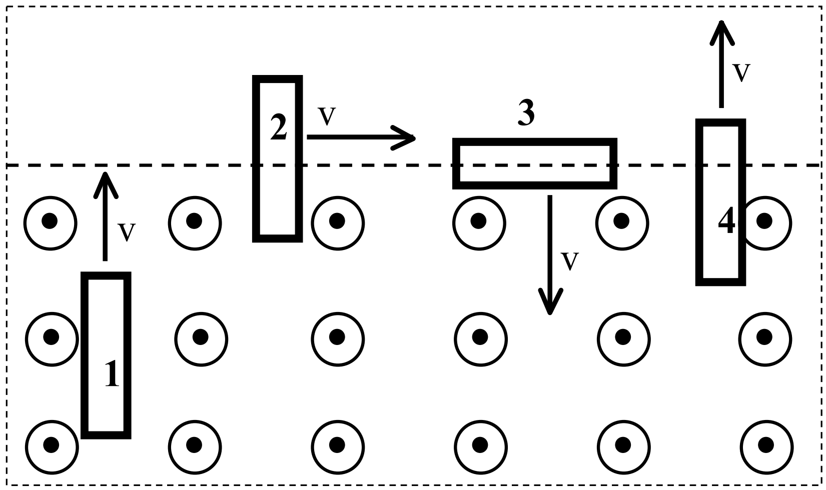
The direction of the <u>net magnetic force</u> on the wire carrying I_3 due to the other two currents is:

(circle just one!) up the page, down the page, left, right, into page, out of page, no net force, some other direction (described below!)

Explain your work briefly but clearly. *(6 pts)*

Your Name____________________ **Your Student ID #** ____________________

<u>Problem 2:</u> Four identical conducting loops move through a region with a magnetic field. There is NO magnetic field in the upper region I, but there is a uniform magnetic field pointing out of the page in the lower part (Region II)
Ignore any interaction between the loops, neglect gravity and air resistance.



i) *Circle below for each of the loops* whether the current is flowing clockwise (CW), counterclockwise (CCW), or there is no current flowing at all.

Also *circle* what direction the resulting *net magnetic force on that loop* would point. (We do not ask for explanations in this part!) *(12 pts)*

Loop 1: current direction: CW CCW No current
magnetic force on loop: up, down, left, right, into page, out of page, no force.

Loop 2: current direction: CW CCW No current
magnetic force on loop: up, down, left, right, into page, out of page, no force.

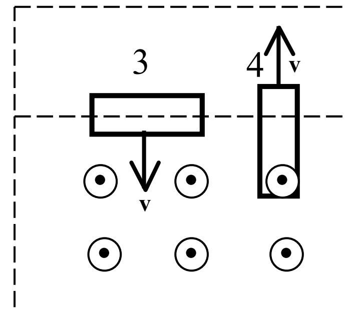
Loop 3: current direction: CW CCW No current
magnetic force on loop: up, down, left, right, into page, out of page, no force.

Loop 4: current direction: CW CCW No current
magnetic force on loop: up, down, left, right, into page, out of page, no force.

(PROBLEM 2 CONTINUES ON NEXT PAGE!!)

Your Name_____________________ **Your Student ID #** _____________________

Problem 2 (continued): Let's focus in on loops 3 and 4 from the previous page. Both loops travel with the *same* speed, in the directions shown in the figure.
Loop 3 is entering the field, and is exaclty halfway in.
Loop 4 is just starting to leave the field (as shown)



ii) Which loop's induced EMF (magnitude) is smaller?
Circle one: ***|EMF|(loop 3) is smaller,***
|EMF| (loop 4) is smaller,
both EMFs have the same magnitude,
ambiguous/not enough information to decide!
Briefly but clearly, explain your reasoning below *(5 pts)*

iii) Now let's focus on loop #3 in the figure. The resistance of loop 3 is R=2 Ω, the magnetic field strength is B= 5 T, and the speed is v=4 m/s. The longer side of the rectangle is 3 m, the shorter side is 1 m. At the moment shown, loop 3 is exactly halfway into the magnetic field region.
Find the magnitude of the net magnetic *force* on loop 3. (Don't forget units!)
Briefly explain your work. (If information is missing, tell us what info you would need, and why.) *(6 pts)*

(END OF EXAM - use as scratch paper if you like)
(If you need more scratch paper, there is some up front)