Instructor(s): Peter Hirschfeld

PHYSICS DEPARTMENT

PHY 2005, Spring 2016 EXAM II March 23, 2016

Name (print, last first): ______________________ Signature: ______________________

On my honor, I have neither given nor received unauthorized aid on this examination.

YOUR TEST NUMBER IS THE 5-DIGIT NUMBER AT THE TOP OF EACH PAGE.

(1) **Code your test number on your answer sheet (use lines 76–80 on the answer sheet for the 5-digit number)**. Code your name on your answer sheet. **DARKEN CIRCLES COMPLETELY**. Code your UFID number on your answer sheet.
(2) Print your name on this sheet and sign it also.
(3) Do all scratch work anywhere on this exam that you like. **Circle your answers on the test form.** At the end of the test, this exam printout is to be turned in. No credit will be given without both answer sheet and printout.
(4) **Blacken the circle of your intended answer completely, using a #2 pencil or blue or black ink**. Do not make any stray marks or some answers may be counted as incorrect.
(5) **The answers are rounded off. Choose the closest to exact. There is no penalty for guessing. If you believe that no listed answer is correct, leave the form blank.**
(6) Hand in the answer sheet separately.

Physical Constants:

$g = 9.8$ m/s^2	$m_e = 9.11 \times 10^{-31}$ Kg
$m_p = 1.67 \times 10^{-27}$ Kg	$e = 1.6 \times 10^{-19}$ C
constant k in Coulomb's Law: $k = 8.99 \times 10^9$ Nm^2/C^2	
$\mu_o = 4\pi \times 10^{-7}$ T·m/A	$\varepsilon_o = 8.85 \times 10^{-12}$ C^2/Nm^2

1. Which one of the following statements concerning the magnetic force on a charged particle in a magnetic field is true?

(1) It depends on the component of the particle's velocity that is perpendicular to the field.
(2) It is a maximum if the particle is stationary.
(3) It is zero if the particle moves perpendicular to the field.
(4) It is a maximum if the particle moves parallel to the field.
(5) It acts in the direction of motion for a positively charged particle.

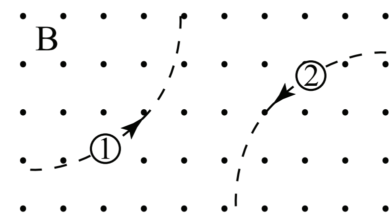
Force on a charged particle is $F_M = qvB$. Since the direction is given by the right hand rule, only the perpendicular component of the particles velocity (i.e. perpendicular to the magnetic field) counts. The correct answer could have said, it depends on the the component of the magnetic field perpendicular to the particle's velocity, and would have been equally correct. All other statements are false.

2. An electron is moving with a speed of 3.5×10^5 m/s when it encounters a magnetic field of 0.60 T. The direction of the magnetic field makes an angle of 60.0° with respect to the velocity of the electron. What is the magnitude of the magnetic force on the electron? (in N)

(1) 2.9×10^{-14} (2) 4.9×10^{-13} (3) 1.7×10^{-13} (4) 3.2×10^{-13} (5) 3.4×10^{-14}

The magnetic force on a moving charged particle in a magnetic field is $F_M = qvB_\perp = qvB\sin\theta = (1.6 \times 10^{-19}\text{C})(3.5 \times 10^5\text{m/s})(0.6\text{T})(0.866) = 2.9 \times 10^{-14}\text{N}$.

3. Two particles move through a uniform magnetic field that is directed out of the plane of the page. The figure shows the paths taken by the two particles as they move through the field. The particles are not subject to any other forces or fields. Which one of the following statements concerning these particles is true?



(1) Particle 1 is negatively charged; 2 is negative.
(2) The particles may both be neutral.
(3) Particle 1 is positively charged; 2 is negative.
(4) Particle 1 is positively charged; 2 is positive.
(5) Particle 1 is negatively charged; 2 is positive.

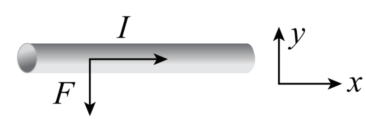
The field is out of the paper. The direction of $\mathbf{v} \times \mathbf{B}$ using the right hand rule is therefore always pointing to the *right* as it moves along its path. But we see both particles being pushed to their *left* in the figure. Thus they must both be negative since $F_M = q\mathbf{v} \times \mathbf{B}$.

4. The local radio station WUFT broadcasts at approximately 90MHz = 9×10^7 Hz. Which is closest to the wavelength of these radio waves?

(1) 3m (2) 3 cm (3) 3 mm (4) 3 km (5) 3 nm

$c = f\lambda$ so $\lambda = c/f = (3 \times 10^8 \text{m/s})/(9 \times 10^7 \text{s}^{-1}) = 3\text{m}$

5. A long, straight wire carries a 6.0 A current that is directed in the positive x direction. When a uniform magnetic field is applied perpendicular to a 3.0-m segment of the wire, the magnetic force on the segment is 0.36 N, directed in the negative y direction, as shown. What are the magnitude and direction of the magnetic field?



(1) 0.020 T, out of the paper
(2) 0.060 T, out of the paper
(3) 0.65 T, out of the paper
(4) 0.020 T, into the paper
(5) 0.060 T, into the paper

The magnitude of B is obtained by noting that the magnetic force on a current carrying wire is $F_M = I\ell B$, so $B = F_M/(I\ell)$ =(0.36 N)/(6 A $\cdot$ 3 m)=0.02 T. The direction is obtained by the right hand rule, B out of paper gives force pointing down.

6. An overhead electric power line carries a maximum current of 125 A. What is the magnitude of the maximum magnetic field at a point 4.50 m directly below the power line? (in tesla)

(1) 5.56×10^{-6} (2) 3.49×10^{-5} (3) 7.95×10^{-3} (4) 1.75×10^{-5} (5) 4.69×10^{-4}

The magnetic field produced by a current carrying wire is $B = \mu_0 I/(2\pi r)$, where r is the distance from the wire. So at a distance 4.5m away, the field is $(4\pi \times 10^{-7}$ T/A-m) (125 A)/(2 π (4.5 m)) = 5.56×10^{-6} T.

7. A di-valent ion with $q = +2e$ and m = 19×10^{-27} kg is moving with a speed 5×10^4 m/s perpendicular to a magnetic field. What must be the magnitude of the field if the particle is to follow a circle with 0.5 m radius? (in tesla)

(1) 0.0059 (2) 0.012 (3) 0.09 (4) 0.0036 (5) 0.072

Since the velocity is perpendicular to the field, and the force is perpendicular to both, the particle moves in a circle. This means that the magnetic force must be providing the centripetal force, i.e. $qvB = mv^2/R$. Therefore $B = mv/(qR) = (19 \times 10^{-27})\text{kg}(5 \times 10^4 \text{m/s})/((2 \cdot 1.6 \times 10^{-19} C)(0.5\text{m}) = 0.0059$ T.

8. Two parallel wires lie 5 cm apart on a tabletop. They carry 5 A current in each wire in the same direction. Now the current has increased to 15 A in each wire. The force acting on each wire

(1) is 9 times larger than that with 5 A current in each wire.
(2) is 3 times larger than that with 5 A current in each wire.
(3) is exactly same as that with 5 A current in each wire.
(4) is now in the opposite direction.
(5) is 2 times larger than that with 5 A current and in the opposite direction.

The first wire, carrying current I, produces a magnetic field $\mu_0 I/(2\pi r)$, which has the value $\mu_0 I/(2\pi d)$, where d is the distance between the wires, at the position of the 2nd wire. Therefore a segment of the 2nd wire of length ℓ, also carrying current I, feels a force $F_M = I\ell B = (\mu_0 \ell B/(2\pi d))I^2$. The force is $\propto I^2$, so if the current in each increases by a factor of 3, the total force increases by 9.

9. A 2 m long straight conducting wire is moving sideways with a constant speed perpendicular to a magnetic field of $B = 0.5$ T. The electric potential induced across the wire is 9 V. What is the speed of the moving wire? (in m/s)

(1) 9 (2) 36 (3) 7.6 (4) 1.8 (5) 3.9

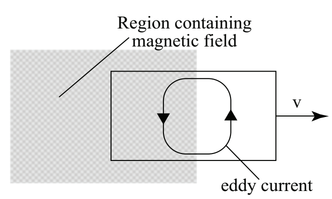
As in class: each electron in the wire is moving with the speed of the wire itself through the magnetic field. It therefore experiences a force $F_M = evB$ pushing it towards one end of the wire, thereby inducing the buildup of emf due to the separation of charges. The process stops when the electric force $eE = eV_{ind}/\ell$ equals the magnetic force evB. Setting the two equal, we find the speed is $v = V_{ind}/(B\ell) = (9\text{V})/((0.5\text{ T})(2\text{ m}) = 9$ m/s.

10. A flat loop of wire has an area of 40 cm^2. It is in a region where $B = 400$ G and is directed a long the $x - axis$. Call θ the angle between the axis of the loop and the $x - axis$. What is the change in flux through the loop as θ is changed from 30° to 60°? (in Tm^2)

(1) -5.86×10^{-5} (2) -4.67×10^{-6} (3) 5.6×10^{-6} (4) 1.42×10^{-4} (5) 3.3×10^{-3}

Flux intially = $AB\cos 30°$, flux finally = $AB\cos 60°$, so change is $\Delta\Phi = \Phi_f - \Phi_i = AB(\cos 60° - \cos 30°) = (40 \times 10^{-4}\text{m}^2)$ (4×10^{-2})T $(\cos 60° - \cos 30°)$= -5.86 $\times 10^{-5}$T-m^2.

11. A sheet of copper is pulled at constant velocity v from a region that contains a uniform magnetic field. At the instant shown in the figure, the sheet is partially in and partially out of the field. The induced emf in the sheet leads to the eddy current shown. Which one of the following statements concerning the direction of the magnetic field is true?



(1) The magnetic field points out of the paper.
(2) The magnetic field points to the right.
(3) The magnetic field points to the left.
(4) The magnetic field points into the paper.
(5) The direction of the magnetic field cannot be determined from the information given.

Because the copper is being pulled out of the field, the flux is decreasing in magnitude. The eddy current shown creates a magnetic field pointing out of the paper by the right hand rule. By Lenz's law, it must be trying to compensate for the change in flux, i.e. the flux must be decreasing out of the paper, so that the field must point in that direction.

12. A vertically polarized light beam is passed through an ideal horizontal polarizer, and no light is transmitted. Another ideal polarizer, this time polarized at 45° with respect to the vertical, is inserted in the beam *before* the horizontal polarizer. What fraction of the intensity is now transmitted?

    (1) 1/4
    (2) zero
    (3) 1/2
    (4) not enough information
    (5) $1/\sqrt{2}$

The vertically polarized beam of intensity I_0 encounters a 45° polarizer, and $I_0 \cos^2 45° = I_0/2$ is transmitted. This beam is now polarized at 45° with respect to the first beam. It now encounters the horizontal polarizer, and exactly as before the intensity is suppressed by a factor of 2, leading to overall $I_0/4$.