A.P. Physics – B

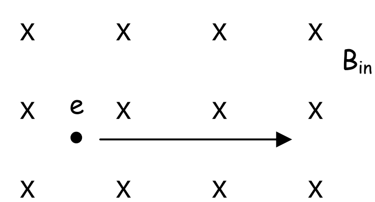
Unit 10 Test Review

Magnetism: Chapters 20-21

Multiple Choice Review: **On this portion of the test, you will not be allowed to use your calculator or AP formula sheet. (You may, however, use your AP table of information.) Approximate $g=10m/s^2$ for simplicity of calculations. No partial credit will be given.**

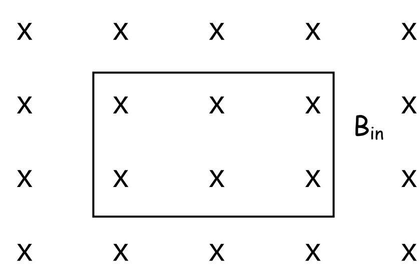
1. An electron is in a uniform magnetic field B that is directed into the plane of the page, as shown. When the electron is moving in the plane of the page in the direction indicated by the arrow, the force on the electron is directed

a. toward the right
b. toward the left
c. out of the page
d. toward the top of the page
e. toward the bottom of the page



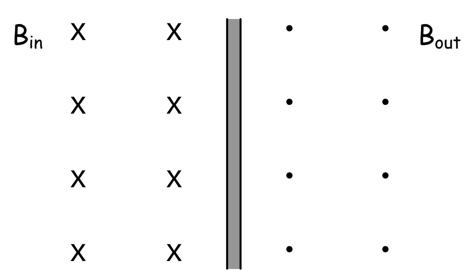
2. A rectangular wire loop is at rest in a uniform magnetic field B of magnitude 2T that is directed into the page. The loop measures 5cm by 8cm, and the plane of the loop is perpendicular to the field, as shown. The total magnetic flux through the loop is

a. zero
b. .002 Wb
c. .008 Wb
d. .2 Wb
e. .8 Wb

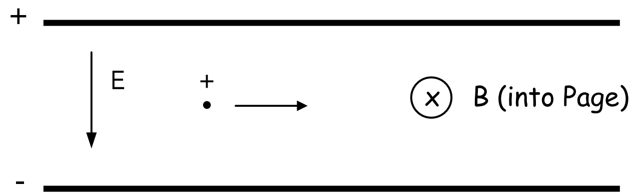


3. What is the direction of the current in the wire shown in the given diagram, if it causes a B-field as shown?

a. Down the page.
b. Up the page.
c. Out of the page.
d. Into the page.
e. To the right of the page.

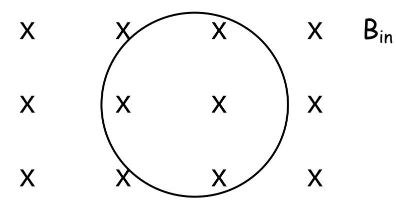


4. As shown, a positively charged particle moves to the right without deflection through a pair of charged plates. Between the plates are a uniform electric field E of magnitude 6.0N/C and a uniform magnetic field B of magnitude 2.0T, directed into the page, as shown in the figure. The speed of the particle is most nearly



a. 0.33m/s
b. 0.66m/s
c. 3.0m/s
d. 12m/s
e. 18m/s

5. A loop of wire is at rest in a magnetic field, as shown. If the strength of the field is increased, in what direction will current be induced in the loop?



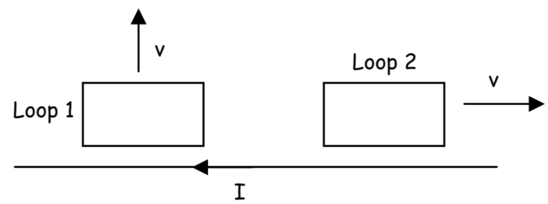
a. Into the page.
b. Out of the page.
c. Clockwise around the loop.
d. Counterclockwise around the loop.
e. No current is induced.

6. Two singly-charged particles are shot with the same velocity into a uniform magnetic field (so that they are moving perpendicular to the field), and it is found that the particles both move in clockwise circular paths of different radii. Which of the following must be true of the two particles.
a. The particles have the same charge sign but different masses.
b. The particles have the same charge sign and the same mass.
c. The particles have different charge signs and different masses.
d. The particles have different charge signs but the same mass.
e. Both particles must be neutrally-charged and massless.

7. A 3cm-long wire carrying a current of 10A is oriented perpendicular to a magnetic field B. If the strength of B decreases from 20T to 0T in 4 seconds, what is the magnitude of the average magnetic force acting on the wire during that time interval?
a. 0.75N
b. 1.5N
c. 3N
d. 15N
e. 30N

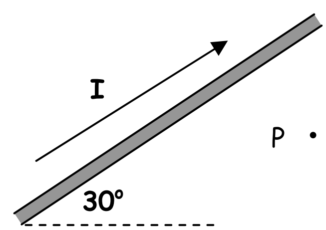
8. Two conducting wire loops move near a very long, straight conducting wire that carries a current I. When the loops are in the positions shown, they are moving in the directions shown with the same constant speed v. Assume that the loops are far enough apart that they do not affect each other. Which of the following is true about the directions of the induced electric currents, if any, in the loops?

	Loop 1	Loop 2
a.	No current	No current
b.	No current	Counterclockwise
c.	Clockwise	No current
d.	Clockwise	Clockwise
e.	Counterclockwise	No current



9. Use the right-hand rule to determine the direction of **B**, caused by **I** in the wire, at point P.

a. Out of the page.
b. Into the page.
c. To the right.
d. At 30° above the positive x-axis.
e. At 60° below the positive x-axis.

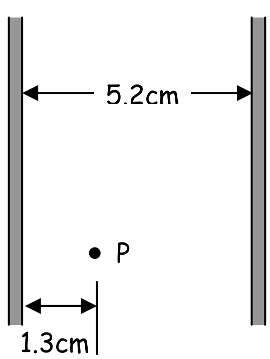


Problem Review: On this portion of the test, you may use your calculator, AP formula sheet, and AP table of information. Partial credit will be given on these problems.

10. A current of 20A is directed along the positive y-axis in a 30cm-long wire, in a region occupied by a 0.05T uniform magnetic field directed at 20° above the negative x-axis. Calculate the magnitude and direction of the magnetic force that acts on this current-carrying wire.

11. A 2.0T magnetic field is directed in the positive x-direction. An electron moving at 5×10^{7} m/s through this magnetic field experiences an instantaneous acceleration of 1.8×10^{15} m/s^2. At what angle above the horizontal is the electron moving? In what direction is the electron's acceleration?

12. Two vertical wires are oriented as shown in the picture, with the wire on the left carrying an upward current of 4A, and the wire on the right carrying an upward current of 3.5A. What are the magnitude and direction of the net magnetic field at point P, created by the two currents?



13. A mass spectrometer is used to examine a particular type of singly-charged particle with a mass of 8.32×10^{-26} kg. After one of these particles is accelerated through a potential difference of 350V, it enters a magnetic field of 0.2T in a direction perpendicular to the field. Calculate the radius of the path of this particle in the field.

14. A 3cm-radius circular loop of wire is placed in a magnetic field of strength 0.6T.

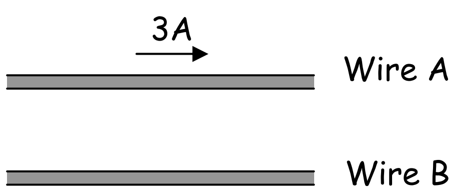
a. What is the minimum possible flux through the loop? Under what conditions is this minimum achieved?

b. What is the maximum possible flux through the loop? Under what conditions is this maximum achieved?

15. A copper wire (mass density = 8900 kg/m^3) has a diameter of 3.1mm. What is the minimum current in the wire that can cause it to float (meaning that it overcomes gravity) in a horizontal magnetic field of 5.0T?

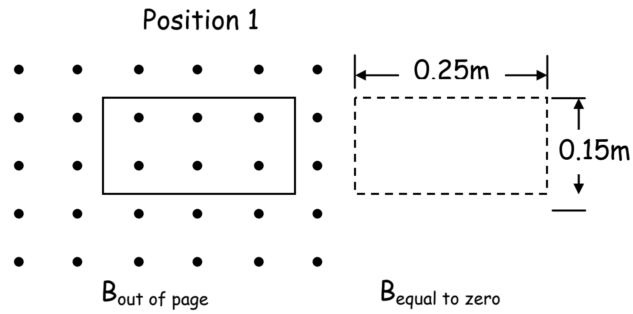
16. A 20-turn circular coil of wire is placed in an external magnetic field of strength 0.25T with the plane of the coil perpendicular to the field direction. If the field strength increases at a rate of 0.04T/s, and if a total emf of 57mV is induced in the coil by this changing B-field, what is the radius of the coil?

17. Two long, straight wires are 12cm apart from one another. There is a current of 3A running to the right through wire A. What current (magnitude and direction) would be necessary in wire B for it to be repelled away from wire A with a force per length of 0.5N/m?



18. In a region where the vertical component of the Earth's magnetic field is 40μT directed straight downward, a 5m length of wire is held in an east-west direction and moved horizontally to the north at a speed of 10m/s. Calculate the induced potential difference between the ends of the wire.

19. Actual A.P. Physics B Free-Response Question (2004):



A 20-turn wire coil in the shape of a rectangle, 0.25m by 0.15m, has a resistance of 5.0Ω. In position 1 shown above, the loop is in a uniform magnetic field **B** of 0.20T. The field is directed out of the page, perpendicular to the plane of the loop. The loop is pulled to the right at a constant velocity, reaching position 2 in 0.50s, where **B** is equal to zero.

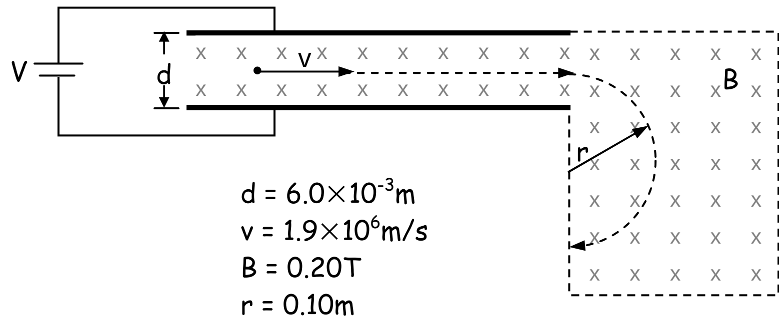
a. Calculate the average emf induced in the 20-turn coil during this 0.5s period.

b. Calculate the magnitude of the current induced in the 20-turn coil.

c. Calculate the magnitude of the average force necessary to remove the 20-turn coil from the magnetic field.

d. Identical wire is used to add 20 more turns of wire to the original coil. How does this affect the current in the coil?

20. Actual A.P. Physics B Free-Response Question, sort of (2000):



A particle with unknown mass moves with constant speed $v = 1.9\times10^{6}$m/s as it passes undeflected through a pair of parallel charged plates, as shown above. The magnitude of the charge on the particle is 2.85×10^{-12}C, but the sign of the charge is yet to be determined through the experiment. The plates are separated by a distance $d = 6.0\times10^{-3}$m, and a constant potential difference V is maintained between them. A uniform magnetic field of magnitude B = 0.20T directed into the page exists both between the plates and in a region to the right of them as shown. After the particle passes into the region to the right of the plates where only the magnetic field exists, its trajectory is circular with radius r = 0.10m.

a. What is the sign of the particle? Check the appropriate space below.

___ Positive ___ Negative ___ It cannot be determined from this information.

Justify your answer.

b. On the diagram above, clearly indicate the direction of the electric field between the plates, and also indicate which plate is positive and which plate is negative.

c. Calculate the magnitude of the electric field between the plates.

d. Determine the mass of the particle.

Answers:

10. $F_B = BI\ell\sin\theta$ = (0.05)(20)(0.3)(sin70) = 0.282N in the positive z-direction (out of the page).

11. The cause of the electron's acceleration is a magnetic force, so start with
$F = ma = (9.11\times10^{-31})(1.8\times10^{15}) = 1.64\times10^{-15}$N.
Then $F_B = qvB\sin\theta$ gives $1.64\times10^{-15} = (1.6\times10^{-19})(5\times10^{-7})(2)(\sin\theta)$
which gives $\theta = 0.0059^\circ$
The direction of the acceleration (which is the same as the direction of the force) is out of the page, or in positive z-dir.

12. $B_1 = \dfrac{(4\pi\times10^{-7})(4)}{(2\pi)(0.013)} = 6.15\times10^{-5}$T into page, and $B_2 = \dfrac{(4\pi\times10^{-7})(3.5)}{(2\pi)(0.039)} =$
1.795×10^{-5}T out of page. So subtract to find $B_{net} = 4.35\times10^{-5}$ T into page.

13. $qV = \frac{1}{2}mv^2$ gives $(1.6\times10^{-19})(350) = \frac{1}{2}(8.32\times10^{-26})v^2$ which leads to
v = 26,690m/s. Then, since the B-field will cause the particle to move in a circular path, use $F_B = ma_c$ which leads to $qvB = m\dfrac{v^2}{r}$
So $(1.6\times10^{-19})(0.2) = (8.32\times10^{-26})(36{,}690)/r$ and r = 9.54cm

14. Zero, when the loop lies in the same plane as B-field (or you could say when the angle between B-field and the normal to the area of the loop is 90°)
b. $\theta = 0^\circ$ when the loop is perpendicular to the B-field , and then $\cos\theta = 1$.
Then the formula becomes $\phi_M = BA\cos\theta = (0.6)(\pi)(0.3^2)(\cos 0) = 0.0017\text{Tm}^2$.

15. The force caused by the B-field must overcome the weight of the wire.
So $F_B = F_g$ which gives $BI\ell = mg$ which gives $BI = \rho Ag$
So $(5)(I) = (8900)(\pi)(.00155^2)(9.8)$ and I = 0.13A

16. The appropriate formula will be $\mathcal{E}_{avg} = \dfrac{\Delta\phi}{\Delta t}$, but it's important to know that
$\mathcal{E}_{avg}$ means the induced emf per turn of coil. So for this problem,
$\mathcal{E}_{avg}$ = 0.057/20 = 0.00285V.
So now, $\mathcal{E}_{avg} = \dfrac{\Delta\phi}{\Delta t} = \dfrac{\Delta BA\cos\theta}{\Delta t} = A\left(\dfrac{\Delta B}{\Delta t}\right)$ so 0.00285 = A(0.04)
and A = 0.07125m². Finish by using $A = \pi r^2$ to get r = 15.1cm.

17. The B-field created by wire A at the position of wire B is found by

$B = \frac{(4\pi\times10^{-7})(3)}{(2\pi)(0.12)} = 5E^{-6}T.$ The force on wire B can now be found by

$F = BI\ell$ which gives $(0.5) = (5E^{-6})(I)$ and $I = 100{,}000A.$

18. $\mathcal{E} = B\ell v = (40\times10^{-6})(5)(10) = 0.002V = 2mV$

19.a. $\mathcal{E}_{avg} = \frac{\Delta\phi}{\Delta t} = \frac{\Delta BA\cos\theta}{\Delta t} = B(\frac{\Delta A}{\Delta t}) = \frac{(0.2)(0-(0.25\times0.15))}{0.5} = 0.015V$

So $\mathcal{E}_{total} = 20(0.015) = 0.3V$

b. I = 0.3/5 = 0.06A CCW
(Direction is found using Lenz's law.)

c. This is a little bit tricky. The force necessary to remove the wire must counteract the magnetic force acting on the current-carrying wire. There will be no force on any of the loop while it's all contained in the B-field, because I is only induced as the loop is being removed from the field. So once the loop is being removed, there's no more force acting on the front side of the loop (because it's already out of the field), and the forces acting on the two sides of the loop will counteract each other, so the only force to consider is the force on the back side of the loop during the removal process. Do it like this…
$F = BI\ell = (0.2)(0.06)(0.15) = 0.0018N.$ But then remember that this is the force on just one turn of the coil, so find $F_{total} = (20)(0.0018) = 0.036N$

d. There's no effect on I, because both $\mathcal{E}$ and R double when the number of turns is doubled.

20.a. Negative, since it's forced downward from its original path (and a positive charge, by the right-hand rule, would have been forced upward).

b. The force caused by the E-field must counteract the force caused by the B-field (so the charge can shoot straight through between the plates), so we need an upward electric force, which means the E-field lines must point downward.

c. $F_{electric} = F_{magnetic}$ so $qE = qvB$ so $E = vB = (1.9E^6)(0.2) = 3.8E^5$ N/C

d. $F_B = ma_c$ which leads to $qvB = m\frac{v^2}{r}$

So $(2.85E^{-12})(0.2) = (m)(1.9E^6)/(0.1)$ and $m = 3E^{-20}$ kg