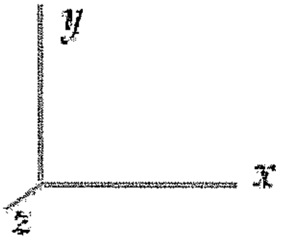
Physics 1520, Spring 2013

Quiz 5, Form: $\boxed{\text{A}}$

Name: Key

Date:

To specify directions, use the coordinate system shown below where $+x$ is to the right, $+y$ is toward the top of the page, and $+z$ is out of the page.

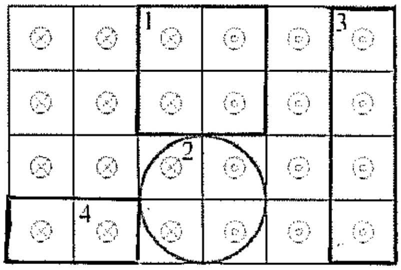


Note the following terminology for directions:

- to the right ($+x$)
- to the left ($-x$)
- upward or toward the top of the page ($+y$)
- downward or toward the top of the page ($-y$)
- out of the page ($+z$) ⊙
- into the page ($-z$) ⊗

Section 1. Multiple Choice

Questions 1–2: The four regions in the figure below are in a magnetic field. On the left half of the figure, the magnetic field is 1 T into the page, and on the right half of the figure, the magnetic field is 2 T out of the page. The grid spacing (i.e. the length of a side of a square bordered by gridlines) is 0.1 m.



1. What is the flux in region 1?

   (a) 0.06 $\text{T}\cdot\text{m}^2$

   (b) zero.

   (c) 0.01 $\text{T}\cdot\text{m}^2$

   [✓ (d)] 0.02 $\text{T}\cdot\text{m}^2$

   (e) 0.03 $\text{T}\cdot\text{m}^2$

$$\Phi = BA\cos\theta$$

on left side, $\theta = 180^\circ$

$\cos(180^\circ) = -1$

on right side, $\theta = 0^\circ$

$\cos(0) = +1$

$$\otimes\ \Phi = (1T)(0.1m)^2(-1) = -0.01\ T\cdot m^2$$

$$\odot\ \Phi = (2T)(0.1m)^2(+1) = +0.02\ T\cdot m^2$$

Total flux is $2(0.02\ T\cdot m^2) + 2(-0.01\ T\cdot m^2) = 0.02\ T\cdot m^2$

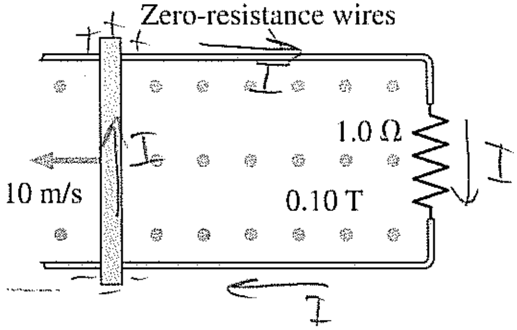
2. Defining out of the page to be the positive direction for magnetic flux, rank the four regions from the most positive flux to the most negative flux.

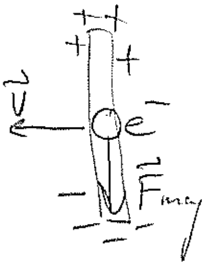
   (a) $3 > 4 > 1 > 2$
   (b) $3 > 4 > 1 = 2$
   (c) $3 = 1 > 2 > 4$
   (d) $3 > 1 = 2 > 4$
   [✓ (e)] $3 > 1 > 2 > 4$

3 is most positive. 4 is most negative. 1 has greater area, so greater flux, than 2.

$3 > 1 > 2 > 4$

Questions 3–6: A moving conductor slides on frictionless metal rails as shown below.





3. Which end of the moving conductor will be negatively charged?

   (a) top end
   [✓ (b)] bottom end
   (c) both ends (top and bottom) will be negatively charged
   (d) both ends (top and bottom) will be positively charged
   (e) both ends will be neutral

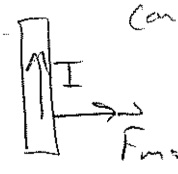
Downward magnetic force on a static electron so bottom becomes neg. charged.

4. In what direction does current flow around the circuit?

   [✓ (a)] clockwise
   (b) counterclockwise
   (c) Neither. There is no battery or other power supply, so no current will flow around the circuit.

5. If the speed of the moving conductor at this instant is 10 m/s and if there is no mechanical device or person pulling on the conductor, the conductor will

   (a) travel with a constant velocity.
   (b) speed up.
   [✓ (c)] slow down. since $\vec{F}_{mag}$ is opposite $\vec{v}$



conventional current is upward so F_{mag} on conductor is to the right, which is opposite $\vec{v}$.

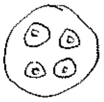
6. If the length of the moving conductor is 20 cm, what is the emf across the conductor?

   (a) 20 V
   (b) 1 V
   (c) 0.1 V
   (d) 0.02 V
   [✓ (e)] 0.2 V

$$emf = vBL$$
$$= (10\,\tfrac{m}{s})(0.1T)(0.2\,m)$$
$$= 0.2\ V$$

Questions 7–8: A circular wire loop, with a single turn, has a radius of 19.0 cm. The loop is in a magnetic field that is decreasing at the rate of 0.500 T/s. At a particular instant in time, the field, which is directed perpendicular to the plane of the loop, has a magnitude of 1.50 T.

7. At this instant, determine the magnitude of the emf induced around the loop.
   (a) 0.30 V
   (b) 0.018 V
   (c) 0.17 V
   (d) 0.085 V
   [✓ (e)] 0.057 V



$r = 0.19\,m$

$\frac{\Delta B}{\Delta t} = -0.5 \frac{T}{s}$

$\theta = 0°, \cos(0) = 1$

$emf = \left|\frac{\Delta \Phi}{\Delta t}\right| = \left|A \frac{\Delta B}{\Delta t}\right|$

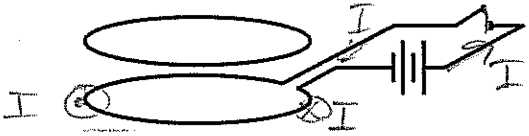
$= \pi (0.19\,m)^2 (0.5 \frac{T}{s})$

$= 0.057\ V$

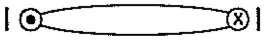
8. If the wire loop were a coil with 50 turns, the magnitude of the emf induced around the coil at this instant would be
   [✓ (a)] 50 times the emf around a single wire loop.
   (b) equal to the emf around a single wire loop.
   (c) 1/50 times the emf around a single wire loop.

it's like 50 batteries in series.

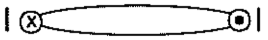
Questions 9–10: A primary coil (bottom coil) is used to induce current in a secondary coil (top coil) as shown below. (This technique is sometimes used to program pacemakers, which are beneath the skin, for example.)



9. In a short time interval during which the switch is being closed, what is the induced current in the secondary coil?
   (a)

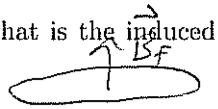


   [✓ (b)]



   (c) Neither, because the induced current in the secondary coil is zero.

$B_i = 0$ then



so $\vec{B}$ increased

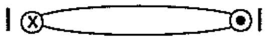
$\Delta\vec{B} \uparrow \uparrow \vec{B}$

$\downarrow -\Delta\vec{B}$

use RHR with thumb as $-\Delta\vec{B}$

10. After the switch has been closed and the current in the primary coil is constant, what is the induced current in the secondary coil?
   (a)

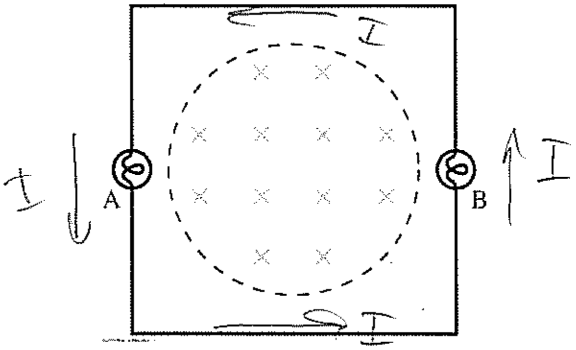
   (b)



   [✓ (c)] Neither, because the induced current in the secondary coil is zero.

no ΔB if current is constant, so no $\Delta\Phi$ and no induced emf and no induced current.

11. In the image below, the square is a circuit composed of wires and two light bulbs. The circle is a region of uniform magnetic field in the plane of the circuit. The magnetic field is zero outside of this circle.



If current flows counterclockwise around the circuit, is the magnetic field increasing, decreasing, or constant?

[✓ (a)] increasing

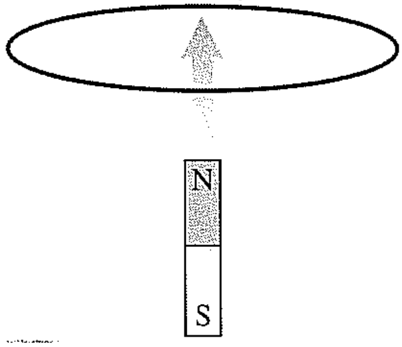
(b) decreasing

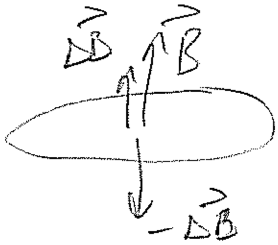
(c) constant

⊙ $-\Delta\vec{B}$ ⊗ $\Delta\vec{B}$

$\Delta\vec{B}$ and $\vec{B}$ are in same direction, so B is increasing

Questions 12–14: A magnet moves toward a wire loop as shown below.

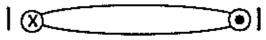




B is increasing

12. What is the direction of the induced current in the loop?

(a) 

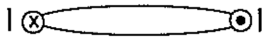
[✓ (b)] 

(c) Neither, because the induced current in the loop is zero.

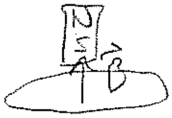
use RHR.

13. Suppose that the magnet travels through the loop and comes out the other side. As it travels away from the loop on the other side, what will be the direction of the induced current in the loop?

[✓ (a)] 

(b) 

(c) Neither, because the induced current in the loop is zero.

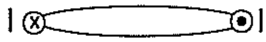


B is decreasing so

$\downarrow \Delta\vec{B}$ $\uparrow -\Delta\vec{B}$

14. What will be the induced current in the loop if the magnet is held at rest at the position shown so that it is neither moving toward nor away from the loop?

(a) 

(b) 

[✓ (c)] Neither, because the induced current in the loop is zero.

B is constant

$\frac{\Delta B}{\Delta t} = 0$ so induced emf $= 0$

Questions 15–16: My favorite web site *thinkgeek.com* sells a green laser pointer with 532 nm wavelength and 5 mW power.

15. What is the energy of a photon emitted by the laser?

(a) 0.005 eV

(b) 5.0 eV

(c) 2.8 eV

[✓ (d)] 2.3 eV

(e) 2.2 eV

$$E = hf = \frac{hc}{\lambda} = \frac{1240\,eV\cdot nm}{532\,nm} = 2.33\,eV$$

16. How many photons are emitted in one second by the laser?

(a) 6.3×10^{18} photons

(b) 3.1×10^{16} photons

[✓ (c)] 1.3×10^{16} photons

(d) 5.9×10^{13} photons

(e) 466 photons

$$(2.33\,eV)\left(\frac{1.6\times10^{-19}J}{eV}\right) = 3.73\times10^{-19}J$$

$$\left(0.005\,\frac{J}{s}\right)\left(\frac{1\,photon}{3.73\times10^{-19}J}\right) = 1.34\times10^{16}\,\frac{photons}{s}$$

17. If your goal is to deliver as much energy per photon to a cancer cell as possible, should you use x-ray radiation or gamma radiation?

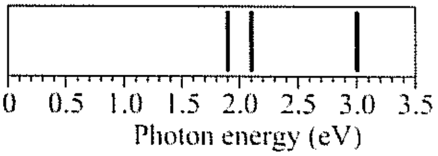
(a) x-ray

[✓ (b)] gamma

(c) Neither, because they will deliver the same energy per photon.

gamma has shorter λ, so greater energy.

18. Spectral lines in the visible region for a hypothetical atom are shown below.



Which of these energy levels are consistent with the visible spectrum?

(a) −6.0 eV, −7.9 eV, −8.4 eV, −9.0 eV

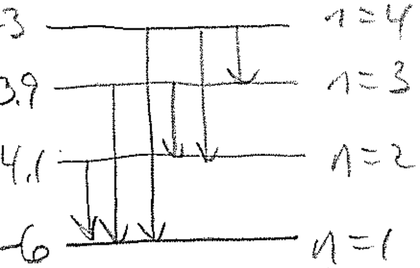
(b) −1.9 eV, −2.4 eV, −3 eV, −6.0 eV

(c) −3.0 eV, −3.6 eV, −4.1 eV, −6.0 eV

[✓ (d)] −3.0 eV, −3.9 eV, −4.1 eV, −6.0 eV

(e) none of the above

If you sketch energy levels and calculate photon energies, these will have a different visible line and will be missing at least one shown in the picture.



Ephoton(eV)

⇒1 : 1.9

3⇒1 : 2.1

⇒1 : 3

⇒2 : 0.2

⇒2 : 1.1

Questions 19–21: Suppose that an electron in a hydrogen atom transitions from orbit $n = 3$ to orbit $n = 6$.

19. In this case, did the atom absorb a photon or emit a photon? (We will assume it is not due to a collision or some other means.)
    - [✓ (a)] It absorbed a photon.
    - (b) It emitted a photon.

The atom gained energy.

20. What wavelength photon was absorbed or emitted?
    - (a) 1010 nm
    - (b) 1280 nm
    - [✓ (c)] 1094 nm
    - (d) 3280 nm
    - (e) 826 nm

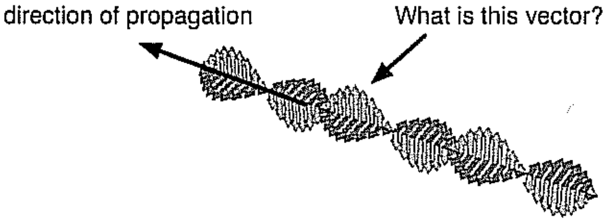
$$|\Delta E| = \left| \frac{-13.6 eV}{6^2} - \frac{-13.6 eV}{3^2} \right| = 1.13 eV$$

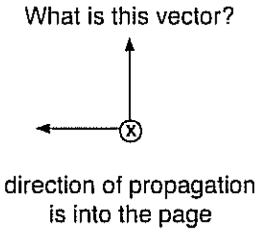
$$E_{photon} = 1.13 eV = \frac{hc}{\lambda} = \frac{1240 eV \cdot nm}{\lambda}$$

$$\lambda = \frac{1240 eV \cdot nm}{1.13 eV} = 1094 nm$$

21. In what region is this photon?
    - (a) gamma
    - (b) x-ray
    - (c) UV
    - (d) visible
    - [✓ (e)] IR

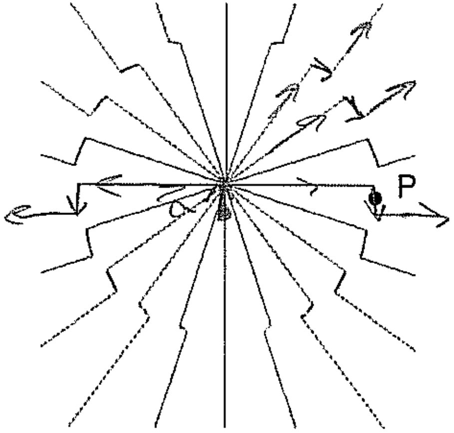
22. A sinusoidal electromagnetic wave at a certain instant of time is shown below in two different views. The direction of propagation is the $-z$ direction. What does the indicated vector (the one in the $+y$ direction) represent?





- (a) electric field
- [✓ (b)] magnetic field
- (c) There is not enough information to determine whether it is electric field or magnetic field.

Questions 23–24: A positively charged particle is briefly accelerated in the $+y$ direction and then travels with a constant velocity. The electric fieldlines a short time after the particle was accelerated are shown below.



field lines point outward and are continuous, so at P, $\vec{E}$ points in $-y$ dir.

23. At point P, what is the direction of the electric field?
    - (a) $+x$ direction
    - (b) $-x$ direction
    - (c) $+y$ direction
    - [✓ (d)] $-y$ direction
    - (e) $+z$ direction

24. If electrons in the antenna on your cell phone accelerate, they produce radiation (in the radio region of the EM spectrum). How long does it take for the radiation to travel to the nearest cell tower if the tower is 1 mile away? (1 mile = 1.6 km)
    - (a) 1.9×10^{-5} s
    - (b) 3.3×10^{-9} s
    - (c) 6.3×10^{-4} s
    - (d) 3.3×10^{-6} s
    - [✓ (e)] 5.3×10^{-6} s

$$c = \frac{\Delta x}{\Delta t} \qquad \Delta t = \frac{\Delta x}{c} = \frac{1600\ m}{3\times10^{8}\ \frac{m}{s}}$$

$$\approx 5.33\times10^{-6}\ s$$

25. The peak wavelength of light emitted by the Sun is at 502 nm. What is the temperature (of the photosphere) of the Sun?
    - (a) 5.8×10^{6} K
    - (b) 1.5×10^{6} K
    - [✓ (c)] 5800 K
    - (d) 1500 K
    - (e) 17,000 K

$$\lambda_{peak} T = 2.9\times10^{-3}\ m \cdot K$$

$$T = \frac{2.9\times10^{-3}\ m \cdot K}{502\times10^{-9}\ m}$$

$$= 5800\ K$$

Name: Key Quiz Name: 5A Date: ____________

1. A B C [✓ D] E
2. A B C D [✓ E]
3. A [✓ B] C D E
4. [✓ A] B C D E
5. A B [✓ C] D E
6. A B C D [✓ E]
7. A B C D [✓ E]
8. [✓ A] B C D E
9. A [✓ B] C D E
10. A B [✓ C] D E
11. [✓ A] B C D E
12. A [✓ B] C D E
13. [✓ A] B C D E
14. A B [✓ C] D E
15. A B C [✓ D] E
16. A B [✓ C] D E
17. A [✓ B] C D E
18. A B C [✓ D] E
19. [✓ A] B C D E
20. A B [✓ C] D E
21. A B C D [✓ E]
22. A [✓ B] C D E
23. A B C [✓ D] E
24. A B C D [✓ E]
25. A B [✓ C] D E