Physics 1520, ~~Fall~~ Spring 2012

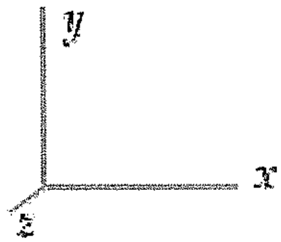
Quiz 5, Form: A

Name: Key

Date: ______________________

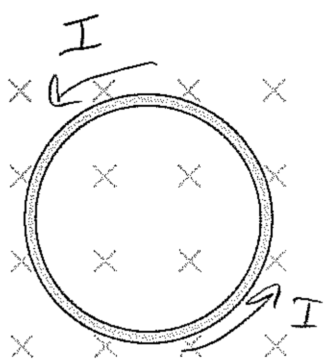
Questions marked with * indicate those that require critical thinking, defined as the application of more than one concept or equation.

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.



Section 1. Multiple Choice

Questions 1–2: A single loop of wire is in a uniform magnetic field as shown below. In a time interval of 0.5 s, the magnetic field increases from 1 T to 3 T. The radius of the loop is 0.05 m, and it has a resistance of 0.2 Ω.



⊗ $\vec{B}$

B increases so $\Delta\vec{B}$ ⊗

and $-\Delta\vec{B}$ ⊙

1. What is the direction of the induced current in the loop?
   - (a) clockwise
   - (b) counterclockwise
   - (c) neither, because the induced current is zero during this time interval

2. *What is the induced current in the loop?
   - (a) 0.031 A
   - (b) 0.079 A
   - (c) 0.16 A
   - (d) 0.24 A
   - (e) 0.31 A

$$|\mathcal{E}| = \left|\frac{\Delta\Phi}{\Delta t}\right| = \left|\frac{\Delta(BA)}{\Delta t}\right| = A\left|\frac{\Delta B}{\Delta t}\right|$$

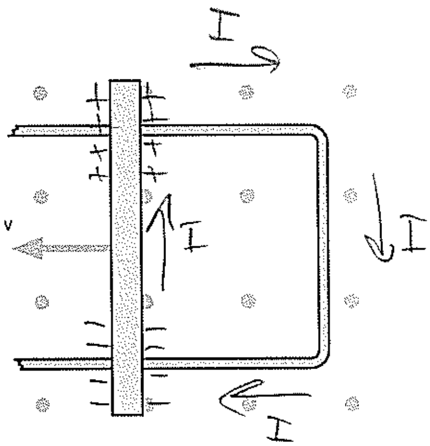
$$= \pi(r)^2\left(\frac{3T-1T}{0.5s}\right)$$

$$= \pi(0.05m)^2\left(4\frac{T}{s}\right) = 0.031\ V$$

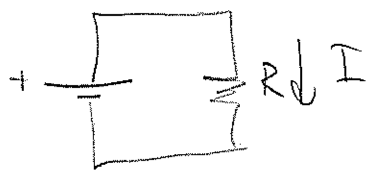
Ohm's law: $\Delta V = IR$ for the wire

$$I = \frac{0.031V}{0.2\Omega} = \boxed{0.157\ A}$$

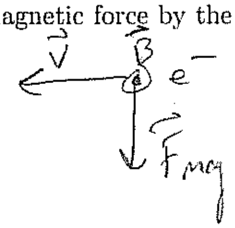
Questions 3–5: A conductor can slide freely on top of a fixed U-shaped wire as shown below. This configuration is called a *slidewire generator*. There is a magnetic field in the $+z$ direction.



like a battery and resistor



3. What is the direction of the magnetic force by the magnetic field on a mobile electron in the moving conductor?



use left-hand rule for an electron

   (a) $+x$
   (b) $-x$
   (c) $+y$
   (d) $-y$
   (e) None of the above because it is zero.

4. In what direction will (conventional) current flow throughout the circuit?

   (a) counterclockwise
   (b) clockwise
   (c) Neither, because the current is zero.

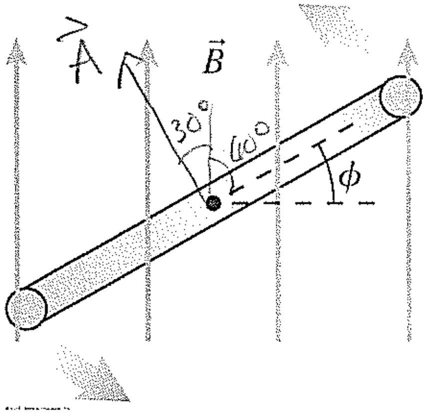
5. The magnetic field is 0.1 T, and the length of the moving conductor is 10 cm. What must be the speed v of the moving conductor in order to produce an induced emf across the conductor of 2 V?

   (a) 0.02 m/s
   (b) 0.2 m/s
   (c) 0.5 m/s
   (d) 2 m/s
   (e) 200 m/s

$$\mathcal{E} = vBL$$

$$v = \frac{\mathcal{E}}{BL} = \frac{2V}{(0.1T)(0.1m)} = 200\ \frac{m}{s}$$

6. A single loop of wire of radius 0.02 m is in a 0.5-T magnetic field.



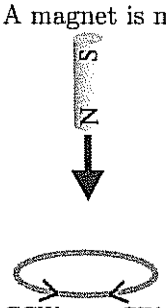
θ with respect to normal is also 30°.

At the instant shown, the angle ϕ is 30°. What is the magnetic flux through the loop?

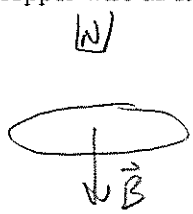
(a) $1.0 \times 10^{-4}\ T \cdot \mathrm{m}^2$
(b) $6.3 \times 10^{-4}\ T \cdot \mathrm{m}^2$
(c) $1.7 \times 10^{-4}\ T \cdot \mathrm{m}^2$
(d) $3.1 \times 10^{-4}\ T \cdot \mathrm{m}^2$
(e) $5.4 \times 10^{-4}\ T \cdot \mathrm{m}^2$

$$\Phi_{mag} = BA\cos\theta = (0.5T)\pi(0.02m)^2\cos(30°) = 5.4\times10^{-4}\ T\cdot m^2$$

7. A magnet is moves toward a loop of copper wire as shown below.



CCW CW

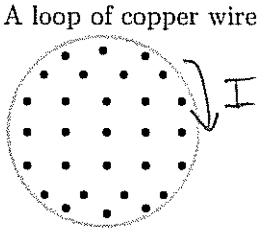


B is increasing.
$\Delta\vec{B} \downarrow$ Use R.H.R.
$-\Delta\vec{B} \uparrow$

Will the induced current flow clockwise or counterclockwise, as defined in the picture?

(a) clockwise
(b) counterclockwise
(c) neither because the induced current is zero

8. A loop of copper wire is in a region of uniform magnetic field in the $+z$ direction, as shown below.

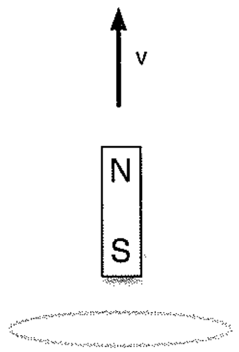


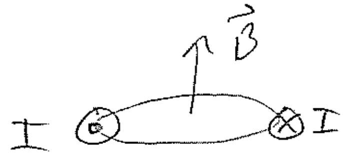
Use R.H.R.
$\otimes - \Delta\vec{B}$
so $\odot\ \Delta\vec{B}$ thus B is increasing

If the induced current in the wire is *clockwise*, is the magnetic field increasing, decreasing, or constant?

(a) increasing
(b) decreasing
(c) zero

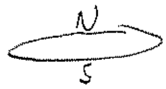
9. *A magnet is moved in the direction shown below. Will the magnet attract or repel the loop?





$\vec{B}$ is decreasing so $\Delta\vec{B} \downarrow$ and $-\Delta\vec{B} \uparrow$

– this makes the loop an electromagnet.



the N end of the loop will attract the S end of the magnet.

(a) attract
(b) repel
(c) neither because they will not exert a force on each other.

10. Suppose that a photon has a wavelength of 300 nm. In what region is this photon?

(a) IR
(b) visible
(c) UV

violet is $\approx 380\,nm$.

11. Which of these regions of the electromagnetic spectrum has the greatest energy?

(a) gamma ray
(b) X-ray
(c) UV
(d) visible
(e) IR
(f) radio

$E_{photon} = \frac{hc}{\lambda}$ shortest λ has greatest energy

12. What is the energy, in eV, of a photon with wavelength 633 nm?

(a) 3.14×10^{-19} eV
(b) 7.85×10^{5} eV
(c) 1.53 eV
(d) 1.60 eV
(e) 1.96 eV

$$E = \frac{hc}{\lambda} = \frac{1240\ eV\cdot nm}{633\ nm} = 1.96\ eV$$

Questions 13–14: At wickedlasers.com, one can buy a red, green, or blue laser pointer. Each of them has the same power of 75 mW.

13. Which laser pointer emits the greatest energy per photon?

    (a) red

    (b) green

    (c) blue

    (d) none of the above because they all have the same energy photons.

$E_{photon} = \frac{hc}{\lambda}$ Shortest λ has greatest energy.

14. Which laser pointer emits the greatest number of photons per second?

    (a) red

    (b) green

    (c) blue

    (d) none of the above because they emit the same number of photons per second

Laser with least energy photon must emit more photons per second in order to emit the same total energy per second (power).

Questions 15–17: Electrons in a photoelectric-effect experiment are ejected from an aluminum surface with a maximum kinetic energy of 1.10 eV. Aluminum has a work function of 4.28 eV.

15. *What is the wavelength of the incident light?

    (a) 1130 nm

    (b) 390 nm

    (c) 290 nm

    (d) 230 nm

    (e) none, because it is impossible for photons to eject electrons from aluminum with this kinetic energy

$K_{max} = E_{photon} - W_0$

$E_{photon} = K_{max} + W_0 = 1.1\,eV + 4.28\,eV = 5.38\,eV$

$E = \frac{hc}{\lambda}$ so $\lambda = \frac{hc}{E} = \frac{1240\,eV\cdot nm}{5.38\,eV} = 230\,nm$

16. What is the maximum wavelength required to eject electrons from aluminum?

    (a) 390 nm

    (b) 230 nm

    (c) 1130 nm

    (d) 290 nm

$K_{max} = 0$

$E_{photon} = W_0 = 4.28\,eV$

$\lambda = \frac{1240\,eV\cdot nm}{4.28\,eV} = 290\,nm$

17. As shown in class, the maximum kinetic energy of an electron is measured by increasing the stopping voltage (or stopping potential) until the current just barely goes to zero. What would be the stopping potential in this example?

    (a) zero

    (b) 5.38 V

    (c) 4.28 V

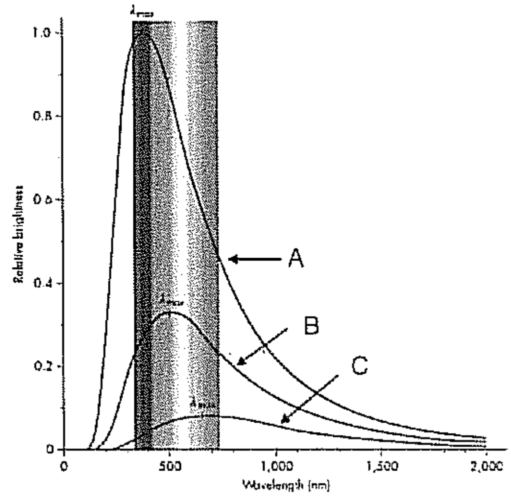
    (d) 3.18 V

    (e) 1.10 V

$K_{max} = 1.1\,eV$ $V_{stop} = \frac{K_{max}}{e}$

so $V_{stop} = 1.1\,V$

18. Three different objects give off light. The brightness as a function of wavelength for each object is measured and graphed below. The shaded region is the visible region of the electromagnetic spectrum.



Which object has the lowest temperature?

(a) A

(b) B

(c) C

(d) They have the same temperature.

19. *An electron of mass 9.11×10^{-31} kg has a kinetic energy of 250 eV. What is the deBroglie wavelength of the electron?

(a) 0.11 nm

(b) 0.049 nm

(c) 0.055 nm

(d) 0.078 nm

(e) 0.098 nm

$K = \frac{p^2}{2m}$ $\quad (250\,eV)\left(\frac{1.6\times10^{-19}\,J}{1\,eV}\right) = 4\times10^{-17}\,J$

$p = \sqrt{2mK} = \sqrt{2(9.11\times10^{-31}\,kg)(4\times10^{-17}\,J)} = 8.55\times10^{-24}\,kg\cdot\frac{m}{s}$

$\lambda = \frac{h}{p} = \frac{6.63\times10^{-34}\,J\cdot s}{8.55\times10^{-24}\,kg\cdot\frac{m}{s}} = 7.77\times10^{-11}\,m$

20. Suppose that you accelerate a proton between two charged plates. As the speed of the proton increases, the proton's wavelength

(a) increases (i.e. gets longer).

(b) decreases (i.e. gets shorter).

(c) stays the same.

$\lambda \propto \frac{1}{v}$

so as $v\uparrow$, $\lambda\downarrow$