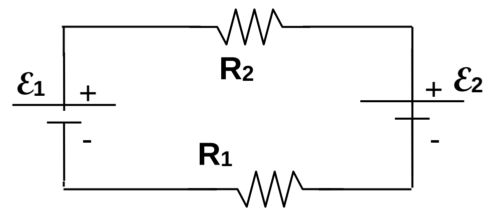
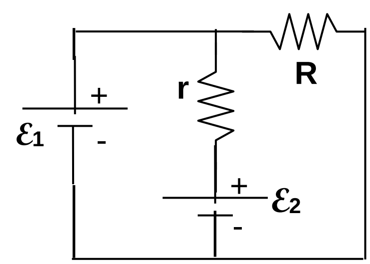
## ▪ Sample Exam, Physics 121 Common Exam 3, b

**1.** The batteries in the sketch have emfs of $\mathcal{E}_1$ = 45 Volts and $\mathcal{E}_2$ = 60 Volts. They have zero internal resistance. The resistances are $R_1$ = 20 Ω and $R_2$ = 10 Ω. Find the magnitude and direction of the current in $R_1$.




A) 1.0 A clockwise
B) 0.3 A clockwise
**C) 0.5 A counterclockwise**
D) 0.3 A counterclockwise
E) 3.5 A counterclockwise

**2.** The figure at right shows an ideal battery (on the left) with $\mathcal{E}_1$ = 4 V connected to a "realistic" battery with $\mathcal{E}_2$ = 1 V and internal resistance r = 2 Ω. The combination is connected to the external resistor R = 4 Ω. Find the current through the "realistic" battery labeled $\mathcal{E}_2$ (center branch on the sketch).




**A) 1.5 A, down**
B) 1.5 A, up
C) 2.5 A, down
D) 2.5 A, up
E) 3.0 A, up

**3.** For the circuit of the previous problem find the current through the ideal battery labeled $\mathcal{E}_1$

A) 1.0 A, down
B) 1.5 A, up
C) 1.5 A, down
**D) 2.5 A, up**
E) 2.5 A, down

**4.** In a series RC circuit, the applied voltage E = 50 V., R = 26 MΩ, and C = 10 μF. The capacitor is initially uncharged. After the switch is closed, how long does it take for the charge on the capacitor to reach 75% of its final value? Select the closest answer:

A) 60 sec
B) 0.6 min
**C) 6 min**
D) 60 min
E) need more information

**5.** A 200 mF capacitor with a charge of 0.2 C is discharged through a resistor of 3.9 kΩ. How long will it take for the voltage on the capacitor to drop to 10% of the initial value? Select the closest answer:

A) 1 s
B) 10 s
C) 1 min
D) 10 min
**E) 30 min**

**6.** A positively charged particle moving from right to left in the plane of the page enters a region of magnetic field which points directly into the page. The particle will:

A) be deflected out of the plane of the page into a circular path
B) continue moving in a straight line, but it will accelerate
C) continue moving in a straight line, but it will decelerate
**D) be deflected down, still in the plane of the page**
E) be deflected up, still in the plane of the page

**7.** A proton moves across the Earth's equator in a northeasterly direction. At this point the Earth's magnetic field points due north and is parallel to the surface. What is the direction of the force acting on the proton at this instant?

A) toward the northwest
**B) out of the Earth's surface**
C) into the Earth's surface
D) toward the northeast
E) zero

**8.** A negatively charged particle (an electron) with charge $-1.6 \times 10^{-19}$ C is moving at a velocity $v = 10^6$ m/s in the positive x direction. It is crossing a region where a uniform magnetic field with B = 500 kT (kilo-Teslas) points in the negative y direction. Find the force acting on the particle.

A) $8.0 \times 10^{-8}$ N, -x direction
B) $8.0 \times 10^{-8}$ N, -y direction
C) $8.0 \times 10^{-8}$ N, +y direction
D) $8.0 \times 10^{-8}$ N, -z direction
**E) $8.0 \times 10^{-8}$ N, +z direction**

**9.** The magnetic field and **speed** are the same as in the previous problem, but the electron's velocity has equal x and y components. The force acting on the particle is closest to:

A) $11.4 \times 10^{-8}$ N, -y direction
B) $5.7 \times 10^{-8}$ N, -x direction
C) $8.0 \times 10^{-8}$ N, -z direction
**D) $5.7 \times 10^{-8}$ N, +z direction**
E) $5.7 \times 10^{-8}$ N, +y direction

**10.** A wire whose length L = 4 m is placed in a uniform magnetic field of magnitude B = 0.5 T. which points out of the page. The wire carries a current of 8 A to the left in the plane of the page. What are the magnitude and direction of the force exerted on the wire by the magnetic field?

A) 0. 16 N, out of the page
B) 0.08 N, up in the plane of the page
C) 0.08 N, down in the plane of the page
**D) 16 N, up in the plane of the page**
E) 16 N, down in the plane of the page

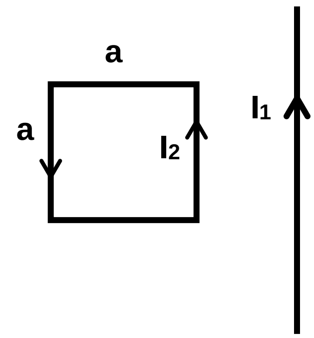
**11.** A proton is moving with a speed of $3 \times 10^5$ m/s in an uniform magnetic field of B = 0.01 Tesla. The field points directly out of the page, and the velocity of the proton lies within in the plane of the page. Find the frequency of revolution and the direction (CW or CCW) The frequency is the reciprocal of the period. The mass of the proton is approximately $1.7 \times 10^{-27}$ kg. The answer is closest to:

A) 150 kHz, CCW
**B) 150 kHz, CW**
C) 150 MHz, CCW
D) 150 MHz, CW
E) the particle keeps moving in a straight line

**12**. Two parallel wires are each 5 meters long. They are separated by a perpendicular distance of 100 cm and carry currents of 40 A. and 50 A. in the same direction. Find the interaction force between the wires:

A) zero
B) 0.2 N, attraction
C) 0.2 N, repulsion
**D) 2 x $10^{-3}$ N, attraction**
E) 2 x $10^{-3}$ N, repulsion

**13**. In the sketch (not to scale) a long straight wire in the plane of the page carries a vertical current $I_1$ = 5 A. A square frame whose side a = 0.2 cm is also in the plane of the page and to the left of the straight wire. It carries a counterclockwise current of $I_2$ = 8 A. and is oriented parallel to the wire. Which of the following statements correctly describes the net force on the frame? Ignore gravitation.

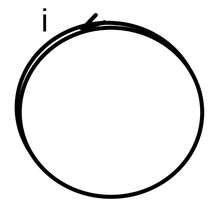



**A) the frame is attracted to the wire**
B) the frame is repelled by the wire
C) the net force on the frame is zero, but there is a torque which attempts to turn it around a vertical axis
D) the net force on the frame is zero, but there is a torque which attempts to turn it around a horizontal axis
E) both the net force and torque are zero

**14.** For the previous problem, calculate the magnitude of the force which acts on the frame if the distance from the straight wire to the closest side of the square is also 0.2 cm = a.

**A) 4.0 x $10^{-6}$ N**
B) 3.2 x $10^{-4}$ N
C) 3.2 x $10^{-3}$ N
D) 2 x $10^{-5}$ N
E) 0 N

**15**. A flat circular coil of wire has 100 turns each of which is carrying current i = 10 A. in the counterclockwise direction as shown. The radius of each loop in the coil is r = 10 mm. The magnetic field at the center of the loop is closest to:




A) zero
**B) 0.063 T , out of the page**
C) 0.063 T , into the page
D) 0.63 mT , into the page
E) 0.63 mT, out of the page

**16.** A long solenoid has 500 turns of wire per meter. It carries a current of 10 A. Find the magnetic field at the center of the solenoid.
A) 0.63 mT
**B) 0.0063 T**
C) 0.063 T
D) 0.63 T
E) 6.3 T

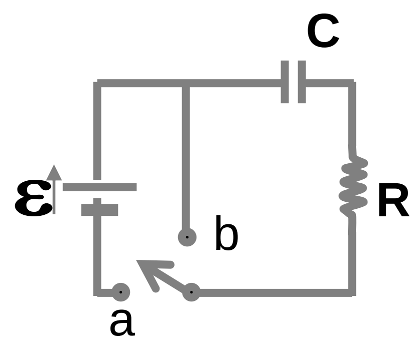
- **Sample Exam, Physics 121 Common Exam 3**

**1.** A beam of electrons passes through a region of uniform magnetic and electrostatic fields at right angles to each other and at right angles to the initial electron velocity. The fields strengths are E = 10,000 V/m and B = $10^{-3}$ T. What will be the speed of electrons that pass through the region without being deflected?

A) 10 m/s
B) 0.1 m/s
C) $3 \times 10^{8}$ m/s
**D) $10^{7}$ m/s**
E) $4\pi \times 10^{-7}$ m/s

**2.** The sketch at right shows a series RC circuit. The applied EMF $\mathcal{E}$ = 12 V., R = 1.0 MΩ, and C = 5.0 μF. The capacitor is initially uncharged. After the switch is closed at point "a", how long does it take for the charging current through the resistor to fall to 30% of its initial value? Select the closest answer:

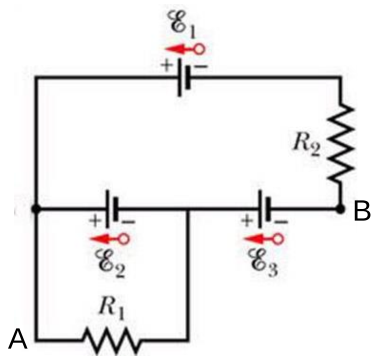
**A) 6.0 sec**
B) 80 sec
C) 0.3 sec
D) 3.0 sec
E) 1.2 sec



**3.** The capacitor in a single-loop *RC* circuit is discharged to 25% of its initial potential difference in 60 s. What is the time constant for this circuit?

A) 0.5 s
B) 60 s
C) 23.0 s
D) 0.043 s
**E) 43.3 s**

**4.** For the circuit shown in the figure, find the current in resistor $R_1$. Let $\mathcal{E}_1$ = 3.0 V, $\mathcal{E}_2$ = 2.0 V, $\mathcal{E}_3$ = 4.0 V, $R_1$ = 10 Ω, and $R_2$ = 5 Ω.

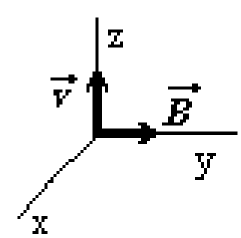



**A) 0.2 A, right**
B) 1.0 A, left
C) 0.5 A, right
D) 2.0 A, up
E) 0.5 A, left

**5.** For points A & B in the circuit of the previous problem, find the potential difference $V_A - V_B$.

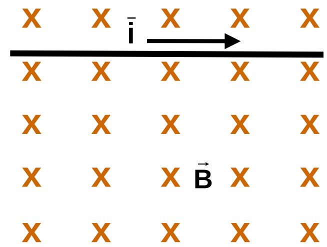
A) 9 V
B) 10 V
C) 11 V
D) 5 V
**E) 6 V**

**6.** A proton is moving with velocity v = 5 x $10^5$ m/s in the positive z direction. It is crossing a region in which a uniform magnetic field with B = 0.20 T points in the positive y direction. Find the force acting on the particle.



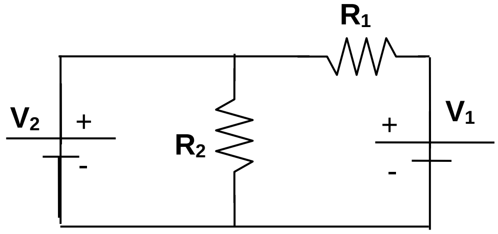

A) $10^{-14}$ N, -z direction
B) 1.6 x $10^{-14}$ N, +x direction
**C) 1.6 x $10^{-14}$ N, -x direction**
D) 8.0 x $10^{-13}$ N, -y direction
E) 8.0 x $10^{-13}$ N, +z direction

**7.** A wire whose length L = 5 cm is placed in a uniform magnetic field of magnitude B = 1 T which points into the page. The wire carries a current of 20 A to the right in the plane of the page. What are the magnitude and direction of the force exerted on the wire by the magnetic field?




A) 1.0 N out of the page
**B) 1.0 N, up in the plane of the page**
C) 1.0N, down in the plane of the page
D) 2.0 N, up in the plane of the page
E) 2.0 N, down in the plane of the page

**8.** In the figure, $V_2 = 4$ V, $V_1 = 3$ V, $R_1 = 2\ \Omega$, and $R_2 = 1.0\ \Omega$. Both batteries are ideal EMFs. Find the current through $R_2$.




A) 4 A, up
**B) 4 A, down**
C) 2 A, up
D) 2 A, down
E) 1.5 A, down

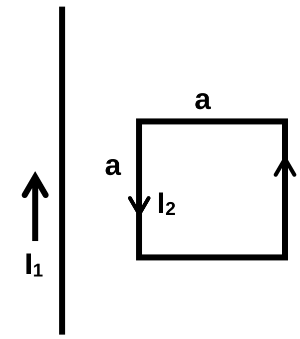
**9.** For the circuit of the previous problem find the current through $R_1$.

A) 0.5 A, to the left
**B) 0.5 A, to the right**
C) 1.0 A, to the left
D) 1.0 A, to the right
E) 4.0 A, to the right

**10.** The uniform magnetic field over a certain region is given by $\underline{\mathbf{B}} = B_x\mathbf{i} + B_y\mathbf{j}$ where $B_x$ = 2 T and $B_y$ = 2 T. An electron moves into the field with a velocity $\underline{\mathbf{v}} = v_x\mathbf{i} + v_y\mathbf{j} + v_z\mathbf{k}$, where $v_x$ = 5 m/s, $v_y$ = 5 m/s and $v_z$ = 5 m/s. The charge on the electron is $-1.6 \times 10^{-19}$ C.
What force **F** does the magnetic field exert on the electron?

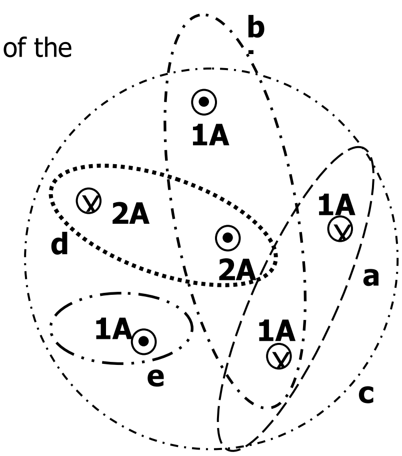
A) $\mathbf{F} = 1.6 \times 10^{-18}\,\mathbf{i} + 1.6 \times 10^{-18}\mathbf{k}$
B) $\mathbf{F} = 1.6 \times 10^{-18}\,\mathbf{i} + 1.6 \times 10^{-18}\,\mathbf{j}$
**C)** $\mathbf{F = 1.6 \times 10^{-18}\,i - 1.6 \times 10^{-18}\,j}$
D) $\mathbf{F} = 2.4 \times 10^{-18}\,\mathbf{i} + 2.4 \times 10^{-18}\mathbf{j} + 2.4 \times 10^{-18}\mathbf{k}$
E) $\mathbf{F} = 2.4 \times 10^{-18}\,\mathbf{j} + 2.4 \times 10^{-18}\,\mathbf{k}$

**11.** In the sketch (not to scale) a long straight wire carries a current $I_1$ upward in the plane of the page. A square wire loop is also in the plane of the page and to the right of the straight wire. It carries a counterclockwise current of $I_2$ and its side is parallel to the wire. Which of the following statements correctly describes the net force on the frame of wire:




A) The net torque on the wire frame attempts to rotate it counterclockwise.
B) The net force on the wire frame is zero, but the net torque attempts to rotate it around a horizontal axis.
C) The net force and torque on the wire frame are both zero.
**D) The frame is repelled by the wire.**
E) The frame is attracted to the wire.

**12.** The sketch shows a cross-section view of 6 wires carrying current into or out of the page. Five possible Amperian paths labeled a, b, c, d, and e are shown.
For which Amperian paths in the picture is $\oint \vec{\mathbf{B}} \circ d\vec{\mathbf{s}} = \mathbf{0}$ in Ampere's Law?

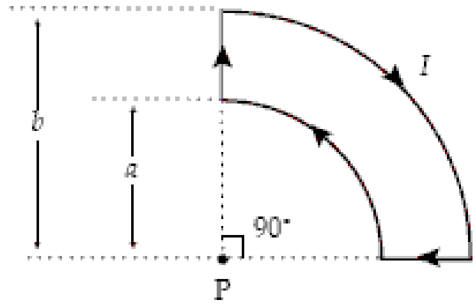



A) d
B) a and c
C) b
D) a, b, and c
**E) c and d**

**13**. A pair of parallel wires are each carrying currents of 10 A in opposite directions. The wires are separated by a perpendicular distance of 0.5 cm. The force per unit length between the wires is:

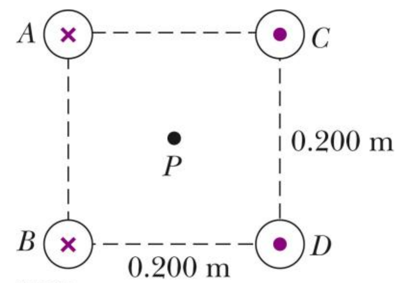
**A) 0.004 N/m, repulsion**
B) 0.004 N/m, attraction
C) 0.001 N/m, repulsion
D) 0.001 N/m, attraction
E) zero

**14.** If a = 1.0 cm, b = 3.0 cm, and I = 30 A, what is the magnitude of the magnetic field at point P, the center of curvature for the arc segments?




A) 0.62 mT
B) 0.59 mT
C) 0.35 mT
**D) 0.31 mT**
E) 0.10 mT

**15.** The sketch shows four very long parallel wires carrying equal currents of I = 1.0 A that are flowing into or out of the plane of the sketch. The wires are located at the corners of a square, each side of which is 0.200 m long. Current flows into the sketch at A and B, and flows out of the sketch at C and D. Find the magnitude and direction of the net magnetic field at point P – the center of the square.




A) 0 T
**B) $4.0 \times 10^{-6}$ T. down**
C) $1.0 \times 10^{-6}$ T. up
D) $1.0 \times 10^{-5}$ T. down
E) $4.0 \times 10^{-5}$ T. up

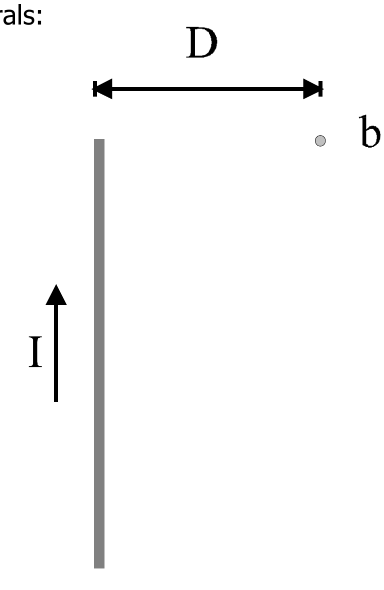
**16.** A wire is bent to form a circular loop whose radius is 5 cm. The wire carries a current of 10.0 A. The resulting current loop is placed in a uniform magnetic field of 12 T, with its magnetic dipole moment vector making an angle of 30° With the direction of the field. Find the magnitude of the torque that the magnetic field exerts on the wire.

A) 1.88 N.m
B) 0.94 N.m
**C) 0.47 N.m**
D) 0.16 N.m
E) 0.0 N.m

**17.** A solid wire conductor has radius R = 5 mm. The wire carries a current of 0.3 A which is uniformly distributed over the cross-section of the wire (current density is constant). What is the magnitude of the magnetic field due to the current in the wire at a radial distance of r = 2 mm from the center axis of the wire? HINT: Use Ampere's law, noting that B is tangential.

**A) 4.8 μT**
B) 6 μT
C) 12 μT
D) 30 μT
E) 0

**18.** A segment of wire of length 5 cm has a current of 0.5 A flowing in the wire as shown in the figure below. What is the magnitude of the magnetic field due to this wire segment at point (b) which is D = 3 cm from the end of the wire? HINT: Use the Biot-Savart Law and look on your equation sheet for some helpful integrals:




A) B = 0.8 μT
B) B = 1.6 μT
C) B = 1.7 μT
D) B = 3.3 μT
**E) B = 1.4 μT**

# Physics 121 Common Exam 3 Formulas, page 1 of 2

Area of circle = $\pi r^2$   Circumference of circle = $2\pi r$   1 meter = 1000 mm = 100 cm   1 kg = 1000 g
Surface area of sphere = $4\pi r^2$   Volume of sphere = $(4/3)\pi r^3$, 1 $\mu$C = $10^{-6}$ C   1 nC = $10^{-9}$ C
$1/4\pi\varepsilon_0 = k_e = 9 \times 10^9$ N-m$^2$/C$^2$ ,   $\varepsilon_0 = 8.85 \times 10^{-12}$ C$^2$/N-m$^2$,  $\mu_0 = 4\pi \times 10^{-7}$ T-m/A
$e = 1.60 \times 10^{-19}$ C, $m_{electron} = 9.11 \times 10^{-31}$ kg, $m_{proton} = 1.67 \times 10^{-27}$ kg, 1 electron volt (eV) = $1.60\times10^{-19}$ J.

Point charges: $\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\hat{r}$   $\vec{E} = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}\hat{r}$  **where $\hat{r}$ is a unit vector**   $k_e \equiv \frac{1}{4\pi\varepsilon_0} = 9\times10^9$

Superposition: contributions to the field or force from point charges add as vectors at a point of interest   $\vec{F}_{net\ on\ 1} = \sum_{i=2}^{n}\vec{F}_{1,i} = \vec{F}_{1,2} + \vec{F}_{1,3} + \vec{F}_{1,4+.....}$

Shell Theorem (spheres only): mimics point charge outside; inside **E** or **F** is zero

**E** = force per unit test charge at a point   **F** = q**E**   $F_{net}$ = m**a**

Dipole moment:  **p** = q**d**   $\tau_{dipole}$ = **p**X**E**   $U_{dipole}$ = -**p**.**E**   $E_{on\ dipole\ axis} \approx +\frac{p}{2\pi\varepsilon_0}\frac{1}{z^3}$ for large z

For continuous charge distributions: $\vec{E} = \int_{dist} k_e \frac{dq}{r^2}\hat{r}$ and $V = \int_{dist} k_e \frac{dq}{r}$ (integrate over the distribution)

$\sigma$ = surface charge density   $E_{cond\ sheet} = \sigma/\varepsilon_0$   $E_{non\text{-}cond\ sheet} = \sigma/2\varepsilon_0$
$\lambda$ = linear charge density   $E_{infinite\ line} = \lambda/2\pi\varepsilon_0 r$   $E_{finite\ line} = \lambda\sin(\theta_0)/2\pi\varepsilon_0 d$   $E_{arc} = \lambda\sin(\theta_0)/2\pi\varepsilon_0 R$
$d\Phi_E$ = **E . n**dA = EAcos($\phi$)   $\Phi_E$ = electric flux = $q_{enc}/\varepsilon_0 = \oint$ **E . dA** over a Gaussian surface

$\Delta V = \Delta U/q = -\oint E\cos\theta\, ds = -\oint$ **E. ds**   $\Delta U_{el} = q\Delta V$   $V = k_e Q/r$   $U = k_e Qq/r$   $V = -E\,\Delta x$

$E_x = -\partial V/\partial x$   $E_y = -\partial V/\partial y$   $E_z = -\partial V/\partial z$   Q = CV   Electrostatic PE: $U_{el} = Q^2/2C = CV^2/2$

$\Delta W_{nc} = \Delta E_{mech} = \Delta K + \Delta U$   $C_{parallel} = \Sigma C_i$   $1/C_{series} = \Sigma(1/C_i)$   $C_{series} = C_1C_2/(C_1+C_2)$
$C_{parallel\ plates} = \kappa\varepsilon_0 A/d$   $C_{sphere} = 4\pi\varepsilon_0 R$   Dielectric constant: $C_{die;} = \kappa C_{vac}$   $\kappa >= 1$

$q = \oint i\,dt = i\Delta t$   dq = idt   i = dq/dt   $i = \oint J \bullet d^2A = J\Delta A$   $J = qnv_{drift}$   $J = \sigma E$   $\sigma = 1/\rho$

R = V / i   V = iR   R = $\rho$L/A   $\rho = \rho_0(1 + \alpha(T - T_0))$   Ohms Law: R independent of V

$R_{series} = \Sigma R_i$   $1/R_{parallel} = \Sigma 1/R_i$   $R_{para} = R_1R_2/(R_1 + R_2)$   $P = dU_{el}/dt = iV$   $P_{resistor} = i^2R = V^2/R$

Junction rule: $\Sigma i_{in} = \Sigma i_{out}$   Loop rule: $\Sigma\,\Delta V_i = 0$ around any closed-circuit path. $\Delta V = -iR$ when following assumed current, +iR otherwise. Count EMF positive when crossing from – to +, negative otherwise.

RC Circuits:  RC = time constant for circuit

charging : $i(t) = (V/R)e^{-t/RC}$   $Q(t) = CV_{cap}(t) = CV_\infty(1 - e^{-t/RC})$

discharging: $i(t) = (Q_0/RC)e^{-t/RC}$   $Q(t) = Q_0 e^{-t/RC}$

$F_m$ = q **v**x**B**   $F_e$ = q**E**   $F_m$ = i **L**x**B**   $\tau = \mu$x**B**   U = -$\mu$. **B**   |$\mu$| = NiA **normal** to loop = magnetic dipole moment.   Cyclotron motion: r = mv/(qB) period = $2\pi$m/(qB) □$\omega$ = qB/m   f = $\omega/2\pi = 1/$period

Biot Savart: $d\vec{B} = \frac{\mu_0}{4\pi}\frac{i\,d\vec{s}\times\hat{r}}{r^2}$ where dB is along $d\vec{s}\times\hat{r}$   $\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$   $\mu_0 = 4\pi \times 10^{-7}$ T-m/A

$F/L = \mu_0 i_1 i_2/2\pi d$ (2 parallel, straight wires) Barc = $\mu_0 i\phi/4\pi R$   $B_{circle} = \mu_0 i/2R$   $B_{solenoid} = \mu_0 in$

$B_{infinite\ wire} = \frac{\mu_0 i}{2\pi r}$

# Physics 121 Common Exam 3 Formulas, page 2 of 2

Magnetic flux: $d\Phi_B = \mathbf{B.dA}$ $\Phi_B = \oint \mathbf{B.dA}$ $\Phi_B = BA\cos(\theta)$ $\Phi_B = 0$ over every *Gaussian* surface

$$\oint \vec{\mathbf{B}} \cdot d\vec{\mathbf{s}} = \mu_0 i_{enclosed}$$

Prefixes: n (nano) = $10^{-9}$ , $\mu$ (micro) = $10^{-6}$ , m (milli) = $10^{-3}$, M (Mega) = $10^{+6}$

Vectors: Components: $a_x$ = a·Dot product: $\mathbf{a}\cdot\mathbf{b} = a\cdot b\cdot\cos(\phi) = axbx + a_y b_y + a_z b_z$ unit vectors: $\mathbf{i}\cdot\mathbf{i} = \mathbf{j}\cdot\mathbf{j} = \mathbf{k}\cdot\mathbf{k} = 1$; $i\cdot\mathbf{j} = \mathbf{i}\cdot\mathbf{k} = \mathbf{j}\cdot\mathbf{k} = 0$

Cross product: $|\,\mathbf{a} \times \mathbf{b}\,| = a\cdot b\cdot\sin(\phi)$; $c = a \times \mathbf{b} = (a_y\cdot b_z - a_z\cdot b_y)\cdot\mathbf{i} + (a_z\cdot b_x - a_x\cdot b_z)\cdot\mathbf{j} + (a_x\cdot b_y - a_y\cdot b_x)\cdot\mathbf{k}$

$\mathbf{a} \times \mathbf{b} = -\,\mathbf{b} \times \mathbf{a}$, $a \times \mathbf{a} = \mathbf{0}$ always; $\mathbf{c} = \mathbf{a} \times \mathbf{b}$ is perpendicular to **a-b** plane; if $\mathbf{a} \parallel \mathbf{b}$ then $|\,\mathbf{a} \times \mathbf{b}\,| = 0$

$\mathbf{i} \times \mathbf{i} = \mathbf{j} \times \mathbf{j} = \mathbf{k} \times \mathbf{k} = 0$, $\mathbf{i} \times \mathbf{j} = \mathbf{k}$ $\mathbf{j} \times \mathbf{k} = \mathbf{i}$ $\mathbf{k} \times \mathbf{i} = \mathbf{j}$