Unit-6: Solutions for G12- Physics exercises.

NB. There are some correction. Correct your work according to these solutions.

Exercises- 6.1

1. A = 0.4m^2, B = 0.06T, φ = ? if.

$a.\ \theta = 90^0$ (B is parallel to the plane means ,it is perpendicular to the normal N)

- φ = BAcosθ → φ= 0.06 x 0.4 x cos90 → φ **= 0**

b. $\theta = 0^0$ (B is perpendicular to the plane means ,it is parallel to the normal N)

- φ = BAcosθ → φ= 0.06 x 0.4 x cos0 → φ **= 0.024Wb**

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2. d = 10cm (r = 5cm), θ= 30^0, B = 5000G (0.5T), φ = ?
   - φ = BAcosθ = Bπr^2cosθ = 0.5 π x 25 x 10^{-4}x 0.866 → $\varphi =$ ¿ **10.825π x 10^{-4}Wb**

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3. A = 2m^2, B = 0.05T, θ = 0^0, φ=? Flux is maximum when B is perpendicular to the normal
   - φ = BAcosθ = 0.05 x 2 φ **= 0.1Wb.**
   - φ = BAcosθ= 0.1 x cos30^0 =0.1 x 0.866 → φ**= 0.0866Wb**
   - φ = BAcosθ= 0.1 x cos90^0 → $\varphi = 0\ Wb$
   - φ = BAcosθ= 0.1 x cos180^0 → φ **= -0.1Wb**

Exercises:6.1.2.

1. **I =** 4A, r= 4cm, μ_0= 4π x 10^{-7}Tm/A, B = ?
   - **B =** $\frac{\mu_0 I}{2\pi r}$ **=** $\frac{4\pi x 10^{-7} x 4}{2\pi x 4 x 10^{-2}}$ → **B = 2 x 10^{-5}T**

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2. L = 20cm, N =100, I = 2A, B = ?
   - B = $\mu_0 \in \frac{¿}{L}$ ¿ = $\frac{4\pi x 10^{-7} x 2 x 100}{0.2}$ → **B =** 4 π x 10^{-4} **T**

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3. B = 2.5mT , r = 30cm, I = ?
   - **B =** $\frac{\mu_0 I}{2\pi r}$ → **I =** $\frac{2\pi r B}{\mu_0}$ **=** $\frac{2\pi x\ 0.3 x\ 2.5 x\ 10^{-3}}{4\pi x 10^{-7}}$ → **I = 3.75 x10^3**A

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4. **L =** 20cm, d = 3cm (r = 1.5cm), N = 5X850=4250, I = 5A, B =? , φ = ?
   - B = $\mu_0 \in \frac{¿}{L}$ ¿ = $\frac{4\pi x 10^{-7} x 5\ X\ 4250}{0.2}$ → **B = 0.0425πT**
   - φ = BA → φ= Bπr^2 = 0.0425π x π x 2.25 x 10^{-4} → φ**= 9.56π^2 x 10^{-6} Wb**

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5. **L = 25cm,** N = 100, I = 2A, B = 2.5T, μ_r = ?
   - B =$\mu_r\ \mu_0 \in \frac{¿}{L}$ ¿ → $\mu_r = \frac{B L}{\mu_0 I N}$ = $\frac{2.5\ X\ 0.25}{4\pi\ X\ 10^{-7} x 2 x 100}$ → μ_r**= 2488**

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6. **n =** 12/cm= 1200/m, I = 6A, B = ?
   - B = $\mu_0 I n$ = 4π x 10^{-7} x 6 x 1200 → B **= 9.04mT**

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7. L = 5cm, N = 200, μ_r= 130, I = 0.3A, B = ?

- B = $\mu_r \mu_0 \in \frac{¿}{L}¿$ = 130 x $\frac{4\pi x 10^{-7} x 0.3 x 200}{0.05}$ → **B = 0.196T**
- Let , B_1 =0.196T, I_1 = 0.3A, B_2 =0.98T, I_2 = ?

  ∴ $\frac{B_1}{B_2} = \frac{I_1}{I_2}$ → **I_2 =** $\frac{B_2}{B_1} I_1 = \frac{0.98 x 0.3}{0.196}$ → I_2 = 1.5A

Exercises; 6.1.2

8. **I_1**= 2.4A, B_1 = 0.5T, B_2 = 0.4T, I_2 = ?

- $\frac{B_1}{B_2} = \frac{I_1}{I_2}$ → $I_2 = \frac{B_2 I_1}{B_1}$ → $I_2 = \frac{0.4 x 2 - 4}{0.5}$ → **I_2 = 1.92A**

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9. r = 5cm, I = 15A, B = ?

- **B =** $\frac{\mu_0 I}{2\pi r} = \frac{4\pi x 10^{-7} x 15}{2\pi x 5 x 10^{-2}}$ → **B = 6 x 10^{-5}T**

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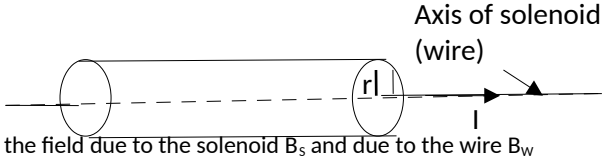
10. N = 2000, L = 60cm, d =2cm (r = 1cm), I = 5A, φ = ?

- φ= BA =($\mu_0 \in \frac{¿}{L}¿$) (πr^2) =($\frac{4\pi x 10^{-7} x 5 x 2000}{0.6}¿$ (3.14 x 10^{-4}) → **φ= 6.4 μWb**

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11. I = 20A, B_s = 4mT, r = 3mm, B = ?

Since magnetic field due to a current through a straight wire is perpendicular to the radial distance from the center, it is also perpendicular to the wire.



But the magnetic field of the solenoid is parallel to its axis. So the field due to the solenoid B_s and due to the wire B_w are perpendicular to each other at any point a distance r from the axis (wire)

- $B_w = \frac{\mu_0 I}{2\pi r} = \frac{4\pi x 10^{-7} x 20}{2\pi x 0.003}$ → B_w = 1.3 x 10^{-3}T

  ∴ B = $\sqrt{B_S^2 + B_W^2}$ = $\sqrt{(4 x 10^{-3})^2 + ¿¿¿}$ → **B =4.2mT**

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12. R = 6cm, B = 30μT, I = ?

- B = $\frac{\mu_0 I}{2\pi r}$ → **I =** $\frac{2\pi r B}{\mu_0}$ → **I =** $\frac{2\pi x 0.06 x 30 x 10^{-6}}{4\pi x 10^{-7}}$ → **I = 9A**

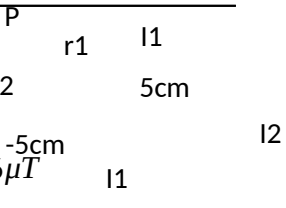
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13. L = 50cm, N = 4000, I = 0.25A, B = ?

- B = $\mu_0 \in \frac{¿}{L}¿$ = $\frac{4\pi x 10^{-7} x 0.25 x 4000}{0.5}$ → **B = 2.5mT**

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14. a) I_1 = I_2 = 12A, x = -5cm, y = 5cm, B = ?



- the magnetic fields due to I_1 and I_2 at point P are both out (right hand rule) . Thus the total field at point P is B = B_1 + B_2

  → B = $\frac{\mu_0 I_1}{2\pi r_1} + \frac{\mu_0 I_2}{2\pi r_2} = \frac{4\pi x 10^{-7} x 12}{2\pi x 0.05} + \frac{4\pi x 10^{-7} x 12}{2\pi x 0.05}$ = **96μT**
- At, x = -7cm & y = -6cm , B_1 is out and B_2 in

  ∴ B = B_1 - B_2 = $\frac{\mu_0 I_1}{2\pi r_1} - \frac{\mu_0 I_2}{2\pi r_2} = \frac{4\pi x 10^{-7} x 12}{2\pi x 0.07} - \frac{4\pi x 10^{-7} x 12}{2\pi x 0.06}$

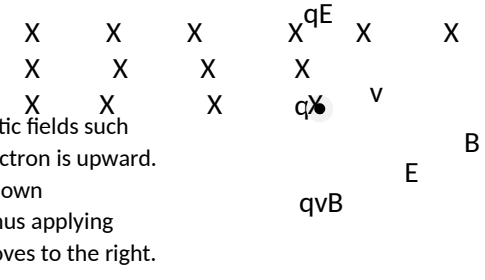
  → **B = 5.7μT**

Exercises:6.3.1

1. E = 7.7KV/m. B = 0.14T , V = ?
   - V = $\frac{E}{B}$ → V = $\frac{7.7x10^3}{0.14}$ → **V = 55000m/s**

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2. E = 1500V/m. B = 0.4Wb/m^2, v = ?
   - V = $\frac{E}{B}$ → V = $\frac{1500}{0.4}$ → **V = 3750m/s**
   - Suppose an electron moves inside a crossed electric and magnetic fields such that E is directed down and B into, the electric force on the electron is upward. So the magnetic force on the electron must be downward as shown in the fig. to balance the electric force acting on the electron. Thus applying left hand rule (for negative charge), shows that the electron moves to the right.



Exercises:6.3.2

1. q = 2.5 x 10^{-8}C, v = 6 x 10^{4}m/s, F = 4.9 x 10^{-3}N, B = ?
   - F = qvB → B = $\frac{F}{qv}$ = $\frac{4.9x10^{-3}}{2.5x10^{-8}x6x10^4}$ → **B = 3.27T**

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2. V= 3750 volt, B = 4 X10^{-3}, q = 1.6 x 10^{-19}C, m$_e$ = 9.11 x 10^{-31}kg, R = ?. T = ?
   - R = $\frac{mv}{qB}$ but, K.E = P.E → $\frac{1}{2}$mv^2 = qV → v = $\sqrt{\frac{2qV}{m}}$ = $\sqrt{\frac{2x1.6x10^{-19}x3750}{9.11x10^{-31}}}$

     → v = 36.29 x10^{6}m/s ∴ R = $\frac{mv}{qB}$ → R = $\frac{9.11x10^{-31}x36.29x10^6}{1.6x10^{-19}x4x10^{-3}}$ → **R = 0.052m**
   - T = $\frac{2\pi m}{qB}$ = $\frac{2x3.14x9.11x10^{-31}}{1.6x10^{-19}x4x10^{-3}}$ → **T = 8.94 x 10^{-9}sec.**
   - ω = $\frac{qB}{m}$ = = $\frac{1.6x10^{-19}x4x10^{-3}}{9.11x10^{-31}}$ → **ω= 7x 10^8 rad/sec**

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3. V = 10KV, B = 0.2T, q = 1.6 x 10^{-19}C, m = 9.11 x 10^{-31}kg, F = ? , R = ? , ω = ?
   - F = qvB , but, v = $\sqrt{\frac{2qV}{m}}$ = $\sqrt{\frac{2x1.6x10^{-19}x10000}{9.11x10^{-31}}}$ → v = 5.9 x 10^{7}m/s

     ∴ F =qvB = 1.6 x 10^{-19}x 5.9 x 10^{7}x 0.2 → **F = 1.9 X 10^{-12}N**. out



   - R = $\frac{mv}{qB}$ $\frac{9.11x10^{-31}x5.9x10^7}{1.6x10^{-19}x0.2}$ → **R = 1.7mm**
   - ω = $\frac{qB}{m}$ = = $\frac{1.6x10^{-19}x0.2}{9.11x10^{-31}}$ → **ω= 3.5x 10^{10} rad/sec or**

     ω=$\frac{v}{R}$ = $\frac{5.9Xx10^7}{17x10^{-4}}$ → ω

     =3.5x10^{10}m/s

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4. V = 5 x 10^{6}m/s, B = 30G (30x10^{-4}T) , q= 1.9 x 10^{-19}C, m$_p$= 1.67 x10^{-27}kg , R = ?, F = ? , a = ?
   - R = $\frac{mv}{qB}$ = $\frac{1.67x10^{-27}x5x10^6}{1.6x10^{-19}x3x10^{-3}}$ → R**= 17.4m**
   - F =qvB = 1.6 x 10^{-19}x 5x 10^{6}x 3x 10^{-3} → **F = 24 X 10-16N**

- a= $\frac{v^2}{R} = \frac{25x10^{12}}{17.4}$ → **a = 1.44x10^{12}m/s^2**

5. B = 1.5T, P.E = 5MeV = 5X10^6 x 1.6x 10^{-19}cv = 8x 10^{-13}J , F = ?
   - F =qvB , v = $\sqrt{\frac{2qV}{m}} = \sqrt{\frac{2P.E}{m}} = \sqrt{\frac{2X8X10^{-13}}{1.67X10^{-27}}} \rightarrow v = 3.1x10^7 m/s$

     B

     (X) V

     ∴ F =qvB = 1.6 x 10^{-19} x 3.1 x10^{7}x 1.5 → **F = 7.44x 10^{-12}N.due east.**

6. q = 1.6 x 10^{-19}C, **V_1= (2.5 k)x10^{7}m**/s, **F_1=(4i + 3i**)x 10^{-13}N, F_1 =¿)x 10^{-13} = 5x10^{-13}N
   - q **V_1Xb = F_1** → q V_1B =F_1 → B = $\frac{F_1}{qV_1} = \frac{5x10^{-13}}{1.6x10^{-19}x2.5x10^7}$ → **B = 0.125T**
   - when **V_2 =(1.5i - 2j**) x 10^{7}m/s, **F_2**= 0 , V_2 = ¿) x 10^7 = **2.5 x 10^{7}m**/s

     q **V_2 x B =F_2** = 0 → **B** and **V_2** are parallel to each other. That is each of their corresponding components makes the same angle with their resultant

     ∴ B_x = B cosθ and V_{2X} = V_2cosα → $\frac{B_x}{V_{2X}} = \frac{Bcos\theta}{V_2 c0s\alpha}$ → $\frac{B_x}{V_{2X}} = \frac{B}{V_2}$, cosθ= cosα

     → $B_X = \frac{V_X}{V_2} B = \frac{1.5x10^7}{2.5x10^7}$ x 0.125 → **B_X = 0.075T**

   Similarly, $B_Y = \frac{V_{2Y}}{V_2} B = \frac{-2}{2.5x10^7}$ x 0.125 → **B_Y = -0.1T**, and $B_K = \frac{V_{2K}}{V_2} B = \frac{0}{V_2} B$ → B = 0

7. V = 5x10^{7}m/s, B = 2T, F = 3x 10^{-12}N, θ = ?
   - F = qvBsinθ → sin$\theta = \frac{F}{qvB} = \frac{3x10^{-12}}{1.6x10^{-19}x5x10^7x2}$ = 0.1875 → θ = Sin^{-1}(0.1875) = **10.8^0**

8. V = 10^{8}m/s east, B = 0.8T, F = ?
   - F = qvB = 1.6x 10^{-19}x 10^{8}x 0.8 → F = 1.28x 10^{-11}N Into.

     F X B
   - F = 1.28 x 10^{11}N out

     V

     F · V

     B

Exercises: 6.4.1

1. I = 10A, B = 0.5T, F/L= ?

x B

I

- F = ILB → **F**/L = IB = 10 x 0.5 → **F/L = 5N/m due south**

2. L = 6cm, m = 1.5g, B = 0.5T, θ = 90^0, I = ?
- F = mg → ILB = mg → I = $\frac{mg}{LB} = \frac{1.5x10^{-3}x10}{0.06x0.5}$ → **I = 0.5A**

3. $I_1 = I_2 = I_3$ = 5A, L_1 =16cm, L_2 = 20cm, F_{net} = ?

   B

   L2

   L1 I1 I2

   I3

   L3
   - L_1 is perpendicular to B, I_2 makes an angle 53^{0}with B, L_3 is along B so no force acts on it. Applying right hand rule for cross product **F** = I (**L X B**), shows that magnetic force F_1 on L_1 is into and force F_2 on L_2 is out. Thus the net force on the triangular loop is

     $F_{net} = F_2 - F_1 = I_2L_2B sin53^0 - I_1L_1B$ = 5 x0.2 x 0.5 x 0.8 – 5 x 0.16 x 0.5 → F_{net} = 0.4 – 0.4 = 0

4. L = 1m, I = 10A, B = 1.5T, θ = 30^0 , F = ?

- F = ILBsin θ = 10 x 1 x 1.5 x0.5 → **F = 7.5N**

5. r = 3cm , $I_1 = I_2$ = 5A, F/L = ?
   - F = $\frac{\mu_0 I_1 I_2 L}{2\pi r}$ → $\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi r} = \frac{4\pi x 10^{-7} x 5 x 5}{2\pi x 0.03}$ → $\frac{F}{L}$ **= 1.67 x 10^{-4}N/m**

6. r= 50cm, F/L = 0.1N/m , $I_1 = I_2$ = ?
   - $\frac{F}{L} = c$ → $I_1^2 = \frac{2\pi r(\frac{F}{L})}{\mu_0} = \frac{2\pi x 0.5 x 0.1}{4\pi x 10^{-7}}$ → I_1^2= 25 x 10^4 → **I_1 = 500A**

7. I_1 (I_A) = 40A, I_2 (I_B) =20A, r = 10cm, $r_1 = r_2$ =5cm , what is B along line C ?

A C B

   - Right hand rule shows that fields due to I_1 and I_2 at any point along line C are **into**. ∴ the total field midway between wires A and B is

I1 I2 r1 r2

$B = B_1 + B_2 = \frac{\mu_0 I_1}{2\pi r_1} + \frac{\mu_0 I_2}{2\pi r_2} = \frac{4\pi x 10^{-7} x 40}{2\pi x 5 x 10^{-2}} - \frac{4\pi x 10^{-7} x 20}{2\pi x 5 x 10^{-2}}$

D A C B

→ **B = 24 x 10^{-5}T , into**

   - Along line D, field due to I_1 is **out** and field due to I_2 is **into**

A C B I1 I2

∴ $B = B_1 - B_2 = \frac{\mu_0 I_1}{2\pi r_1} - \frac{\mu_0 I_2}{2\pi r_2} = \frac{4\pi x 10^{-7} x 40}{2\pi x 8 x 10^{-2}} - \frac{4\pi x 10^{-7} x 20}{2\pi x 18 x 10^{-2}}$

→ **B = 7.8 x 10^{-5} T out**

   - Midway between wires A and B the net fileld due to I_1 and I_2 is **24 x 10^{-5}T into**

I3=5A 8cm 10cm I1 I2 r1 r2

∴ **F/L_C** = I_3B = 5 x 24 x 10^{-5} = 1**.2 x 10^{-3} N/m towards** A

8. L = (0.5j)m, I = 10A, **B = 0.3i – 1.2j + 0.5k**
   - **F** = I (**L X B**)
     → **F** = 10 (**0.5j X (0.3i -1.2j + 0.5k**))
     → **F** = 10 (**-0.15k + 0 + 0.25i**) → **F = 2.5i -1.5k**
   - F = $\sqrt{2.5^2+1.5^2}$ = $\sqrt{8.5}$ → **F = 2.9N**

1. r = 4cm, I_1 = 2A, I_2 = 6A, F/L = ? F/L = $\frac{\mu_0 I_1 I_2}{2\pi r} = \frac{4\pi x 10^{-7} x 2 x 6}{2\pi x 0.04}$ → **F/L = 6 X 10^{-5}N/m**

Exercises:6.4.2

1. A = 40cm^2, B = 0.15T, I = 5A, $\theta = 90^0$, τ = ?. μ = ?
   - $\tau =$ ¿ IAB = 5x 40x 10^{-2}x 0.15 → τ **= 3 x 10^{-3}Nm**
   - μ = IA = 5x 40x10^{-4} → μ **= 0.02Am^2**

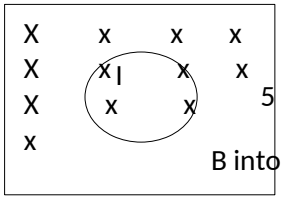
2. **r**= 20cm, B = 0.8T, I = 5A, $\theta = 37^0$ (the plane makes 53^0 with **B** means , B makes 37^0 with the normal N)
   - $\tau =$ ¿ IABsinθ = I$\pi r^2 B$sinθ = 5π x 0.2^2x 0.8x 0.6 → τ**= 0.096** π**Nm**

3. N = 300, A 2.5cm^2, B = 2x10^{-3}T, I = 3A, $\theta = 53^0$, **μ=?, τ= ?**
   - μ = IA = 3 X 2.5X10^{-4} → μ **= 7.5X10^{-4} Am^2**
   - $\tau = N$ IABsinθ= NμBsinθ = 300x7.5x10^{-4}x 2 x10^{-3}x 0.8 → τ**= 3.6x 10^{-4}**

4. **A** 100cm^2, N = 200, I = 10^{-3}A, B = 0.1T, **τ= ? ,** for a maximum torque , $\theta = 90^0$
   - $\tau = N$ IAB = 200x 10^{-3}x 10^{-2} x 0.1 → $\tau =$ ¿ **2 x 10^{-4}**Nm

5. **B** is perpendicular to the plane ,means it is parallel to the normal **(θ =0)**
   - $\tau = N$ IABsinθ= 0 , sin0^0 = 0

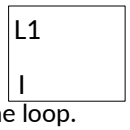
F F 5



- **If** we consider a small length ΔL on the circle, theforce on it is directed to the left as shown (applying right hand rule for a straight current carrying conductor at the small length ΔL). A point directly opposite this small length has On the loop has an equal ,but opposite , force acting on it. Hence the forces on the loop cancel and the resultant force on is zero.

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6. N = 40, I = 2A, B = 0.25T, A = 120cm^2, θ = 90^{0,} τ**= ? , F_{net} = ?**



- $\tau = N$ IAB = 40 x 2 x 120x 10^{-4} x 0.25 $\rightarrow$ τ**= 0.24Nm**
- $L_1 = L_2$ = 12cm, $I_1 = I_2$ =2A, the force on L_1 (left side) is **out,** the Force on L_2(right side) is **into,** no force act on the upper and lower sides of the loop.

$\therefore$ the net force on the loop is $F_{net} = F_1 - F_2 = I_1L_1B - I_2L_2B$

$\rightarrow F\,net = ¿ 2x0.12x0.25 - 2x012x0.25 \rightarrow F\,net = ¿\ 0$

Exercises:6.4.3

1. R = 15cm, ΔL = 20cm, I = 5A, ΔB = ? $\therefore \Delta B = \frac{\mu_0 I \Delta L}{4\pi r^2} = \frac{4\pi x 10^{-7} x 5 x 0.2}{4\pi x 225 x 10^{-4}} \rightarrow \Delta B$ **= 4.4** μT

Exercises:6.4.4

1. R = 10mm, I =1.5A, B = 5 x 10^{-6}T, r = ?
   - B = $\frac{\mu_0 I r}{2\pi R^2}$ $\rightarrow$ r = $\frac{2\pi R^2 B}{\mu_0 I}$ = $\frac{2\pi x 10^{-4} x 5 x 10^{-6}}{4\pi x 10^{-7} x 1.5}$ $\rightarrow r = ¿$ **1.67mm**

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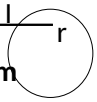
2. R = 4cm , N = 800, I = 6A, B = ?
   - B = N $\frac{\mu_0 I}{2\pi R}$ = $\frac{800 x 4\pi x 10^{-7} x 6}{2\pi x 4 x 10^{-2}}$ $\rightarrow$ B **= 24mT**

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3. L = 30cm, N = 300+250 = 550, I = 3A, B= ? , B = $\mu_0 \in \frac{¿}{L} ¿$ = $\frac{4\pi x 10^{-7} x 3 x 550}{0.3}$ $\rightarrow$ B **= 2.2** π**mT**

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4. N =1, I = 10A, B = $4\pi x 10^{-6} T$, r = ?, B = N $\frac{\mu_0 I}{2r}$ $\rightarrow$ r= N $\frac{\mu_0 I}{2B}$ = $\frac{4\pi x 10^{-7} x 10}{2 x 4\pi x 10^{-6}}$ $\rightarrow$ **r= 0.5m**



   - B = $\frac{\mu_0 I}{2\pi r}$ $\rightarrow$ I = $\frac{2\pi r B}{\mu_0}$ = = $\frac{2\pi x 0.5 x 4\pi x 10^{-6}}{4\pi x 10^{-7}}$ $\rightarrow$ **I = 10**πA

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5. I = 18A, B = 4.5 X 10^{-4}A, r = ?, r= $\frac{\mu_0 I}{2B}$ = $\frac{4\pi x 10^{-7} x 18}{2 x 4.5 x 10^{-4}}$ $\rightarrow$ **r = 8**πmm
6. r= 2cm, I = 20A, B =? The field at P is one-half the field of a circular loop of radius r

$\therefore$ B = $\frac{1}{2}$ ($\frac{\mu_0 I}{2r} ¿$ = $\frac{1}{2}$ ($\frac{4\pi x 10^{-7} x 20}{2 x 0.02} ¿ \rightarrow B$ **= 0.1**πmT

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I_3