Use conversion constants and data from data page. Show all work!! Report all numbers to three (3) significant figures.

(a) Calculate the magnitude of the magnetic field 3.75 cm from the center of a long straight wire carrying a current of 55.7 A.
\[ |B| = \frac{\mu_0 I}{2\pi r} = 247 \text{ mT} \]

(b) Calculate the force per meter on a long straight wire carrying a current of 75.0 A if the magnetic field perpendicular to the wire is 3.25 T.
\[ F = B \times I \hat{z} = 244 \text{ N/m} \]
\( \hat{z} \): unit vector in direction of current

(c) Calculate the magnitude of the magnetic flux through a table 1.00 m by 2.00 m. Take the magnetic field as 0.550 gauss at an angle of 75° from the horizontal surface of the table.
\[ \Phi = \vec{B} \cdot \vec{A} = \vec{B} A \cos(150°) = 1.06 \text{ gauss} \cdot \text{m}^2 \]

(d) A wire carries a current in the direction shown. If the magnitude of this current is increasing, what is the direction (clockwise or counter clockwise) of the current in the wire loop? [Both the wire and loop are in the plane of the paper.]

\[ \text{Flux out of page increasing} \Rightarrow \text{Induced current flowing clockwise} \]

(e) The circuit shown has an inductance of 4.27 mH and a resistance of 15,500 Ω. Calculate the time constant when the switch is closed.
\[ \tau = \frac{L}{R} = 2.75 \times 10^{-7} \text{s} \]
Use conversion constants and data from data page.
Show all work!! Report all numbers to three (3) significant figures.

Electrons are accelerated by a potential difference of 4000 V. They enter a magnetic field of .0275 T perpendicular to their velocity. Calculate the radius of the circle they travel in.

1. Find the velocity when the electron enters the magnetic field:

   \[ \Delta E = 0 = \frac{1}{2} m v^2 - q AV \]

   \[ \frac{1}{2} m v^2 = q AV \]

   \[ v = \sqrt{\frac{2 q AV}{m_e}} \]

2. Now find the radius for circular motion

   \[ F_{net} = \frac{m v^2}{r} \] (condition for circular motion)

   \[ F_{net} = |q v \times B| = q v B \sin 90^\circ = q v B \]

   \[ r = \frac{m v^2}{q v B} = \frac{m e \sqrt{2 q AV}}{q e B} = \frac{9.11 \times 10^{-31} \text{ kg}}{1.60 \times 10^{-19} \text{ C} \times 0.0275 \text{ T} \times 9.11 \times 10^{-31} \text{ kg}} \]

   \[ r = 0.00776 \text{ m} = 7.76 \times 10^{-3} \text{ m} = 7.76 \text{ mm} \]
Use conversion constants and data from data page. Show all work!! Report all numbers to three (3) significant figures.

Given a long, straight, big fat wire carrying a current of 152 Amps uniformly distributed, and has a radius of 1.32 cm.

(a) Calculate the magnetic field inside the wire at \( r = 0.74 \) cm from the center of the wire.
(b) Calculate the energy stored inside a section of wire 9.00 m in length (for all \( r \leq R_o \)).

\[
\oint \vec{B} \cdot d\vec{s} = B \oint ds = B(2\pi r) = \mu_0 I'
\]

\[
B = \frac{\mu_0 I'}{2\pi r}, \quad \frac{I'}{I} = \frac{r^2}{R_o^2} \Rightarrow I' = \frac{r^2}{R_o^2} I
\]

\[
B = \left( \frac{\mu_0 I}{2\pi R_o^2} \right) r = \frac{\mu_0 152 \text{ Amps}}{2\pi (0.0132 \text{ m})^2} \cdot 0.0074 \text{ m}
\]

\[= 1.29 \text{ mT} \]

\[U = \int udV = \int_0^{R_o} \frac{B^2L}{2\mu_0} 2\pi r dr = \left( \frac{\mu_0 I'}{2\pi R_o^2} \right)^2 \frac{4\pi L}{\mu_0} \int_0^{R_o} r^2 dr
\]

\[= \frac{\mu_0 I'^2 L}{32\pi R_o^2} \]

\[
\frac{U}{16 \pi} = 5.20 \text{ mJ}
\]
Use conversion constants and data from data page. Show all work!! Report all numbers to three (3) significant figures.

For the circuit shown, the switch is open for a long time, and then closed at \( t = 0 \).

(a) Calculate the magnitude of current in \( R_2 \) 1.75 time constants after the switch is closed.
(b) If the switch is opened after being closed for a long time, calculate the time constant for decay of the current in the inductance.
(c) Using full loops and junctions, as done in class, calculate the time constant in (a).

\[ \varepsilon = 15.5 \text{ V}; \quad R_1 = 300 \ \Omega; \quad R_2 = 400 \ \Omega; \quad R_3 = 750 \ \Omega; \quad L = 1.45 \text{ mH} \]

\[ S \quad R_1 \quad I_1 \quad R_2 \quad R_3 \quad L \]

\[ I_{eq} = \frac{\varepsilon}{R_{eq}} = 560.87 \ \text{A} \]

\[ I_{eq} = 0.0276 \ \text{A} \]

\[ \Rightarrow \Delta V_1 = R_1 I_1 = 8.29 \text{ V} \]

\[ \Rightarrow \Delta V_2 = \Delta V_3 = \Delta V_{23} = \varepsilon - \Delta V = 7.2 \text{ V} \]

\[ I_2(\infty) = \frac{\Delta V_2}{R_2} = 0.0180 \ \text{A} \]

\[ \Rightarrow I_2(1.75 \varepsilon) = I_2(\infty) \left(1 - e^{-1.75\frac{\varepsilon}{\tau}}\right) = 0.01487 \approx 14.9 \text{ mA} \]

\[ \text{(Total: 6 p)} \]

(b) \[ \tau = \frac{L}{R_{eq}} \]

Since the switch is open, \( R_2 \) and \( R_3 \) are in series, \[ R_{eq} = R_2 + R_3 \]

\[ \Rightarrow \tau = \frac{L}{R_2 + R_3} = 1.26 \cdot 10^{-6} \text{ s} \]

\[ \text{(Total: 4 p)} \]

(c) \[ 1: \quad I_1, -I_2 - I_3 = 0 \]

\[ 2: \quad \varepsilon - I_1 R_1 - I_3 R_3 = 0 \]

\[ 3: \quad I_2 R_2 + L \frac{dI_2}{dt} - I_3 R_3 = 0 \]

\[ 4: \quad I_2 R_2 + L \frac{dI_2}{dt} - \varepsilon R_3 - I_2 R_1 R_3 \left(\frac{1}{R_1 + R_3}\right) = 0 \]

\[ \Rightarrow \frac{dI_2}{dt} + I_2 \left(\frac{R_2 + \frac{R_1 R_3}{R_1 + R_3}}{R_1 + R_3}\right) = \frac{R_3}{R_1 + R_3} \varepsilon \]

\[ = \frac{1}{\tau} \]

\[ \Rightarrow \tau = \frac{L}{R_2 + \frac{R_1 R_3}{R_1 + R_3}} = 2.36 \cdot 10^{-6} \text{ s} \]

\[ \text{(Total: 3 p)} \]

Setting it up different, you can also get \[ \tau = \frac{L}{R_1 R_2 + R_1 R_3 + R_2 R_3} \] which is the same.