Physics Homework#1, T,3

1. **Use the diagram given to find the force per unit length between the two wires shown.**

The force per unit length between two parallel wires carrying current I1 and I2 and separated by a distance d is given by:

$F = \mu_0 \times I1 \times I2 / (2 \times \pi \times d)$

where μ_0 is the permeability of free space ($4\pi \times 10^{-7}$ T m/A).

Substituting the given values, we get:

$F = 4\pi \times 10^{-7}$ T m/A x 3 A x 5 A / (2 x π x 0.05 m)

= 1.2×10^{-4} N/m

Therefore, the force per unit length between the two wires is 1.2×10^{-4} N/m.

2. **The distance between two parallel wires carrying currents of 10 A and 20 A is 10 cm. Determine the magnitude and direction of the magnetic force acting on the length of 1 m of wires, if the currents are carried a) in the same direction, b) in the opposite direction.**

To find the magnetic force between two parallel wires, we can use the formula:

$F = \mu_0 \times I_1 \times I_2 \times L / (2 \times \pi \times d)$

where F is the force, μ_0 is the permeability of free space ($4\pi \times 10^{-7}$ T m/A), I_1 and I_2 are the currents, L is the length of wire, and d is the distance between the wires.

a) If the currents are in the same direction, the force is attractive and given by:

$F = \mu_0 \times I_1 \times I_2 \times L / (2 \times \pi \times d)$

= $4\pi \times 10^{-7} \times 10$ A $\times 20$ A $\times 1$ m / ($2 \times \pi \times 0.1$ m)

$\approx 1.26 \times 10^{-3}$ N

The force is directed towards each other, so the wires will be pulled towards each other.

b) If the currents are in opposite directions, the force is repulsive and given by:

$F = \mu_0 \times I_1 \times I_2 \times L / (2 \times \pi \times d)$

$= 4\pi \times 10^{-7} \times 10\ A \times (-20\ A) \times 1\ m / (2 \times \pi \times 0.1\ m)$

$\approx -2.52 \times 10^{-3}\ N$

The force is directed away from each other, so the wires will be pushed away from each other.

3. The force per meter between the two wires of a jumper cable being used to start a stalled car is 0.225 N/m. (a) What is the current in the wires, given they are separated by 2.00 cm? (b) Is the force attractive or repulsive?

(a) The force per meter between two parallel wires carrying current I and separated by a distance d is given by:

$F = \mu_0 \times I^2 / (2 \times \pi \times d)$

where μ_0 is the permeability of free space ($4\pi \times 10^{-7}$ T m/A).

Rearranging this equation to solve for I, we get:

$I = \sqrt{2 \times \pi \times d \times F / \mu_0}$

Substituting the given values, we get:

$I = \sqrt{2 \times \pi \times 0.02\ m \times 0.225\ N/m / (4\pi \times 10^{-7}\ T\ m/A)}$

$\approx 20\ A$

Therefore, the current in the wires is approximately 20 A.

(b) We can determine if the force is attractive or repulsive by using the right-hand rule for magnetic fields. If we point the thumb of our right hand in the direction of the current in one wire, and the fingers in the direction of the current in the other wire, the force will be in the direction of the palm of our hand.

Since the direction of the force is not specified in the problem, we do not know the direction of the currents in the wires. Therefore, we cannot determine whether the force is attractive or repulsive without additional information.

4. The wire carrying 400 A to the motor of a commuter train feels an attractive force of 4.00 × 10−3 N/m due to a parallel wire carrying 5.00 A to a headlight. (a) How far apart are the wires? (b) Are the currents in the same direction?

(a) The force per meter between two parallel wires carrying current I1 and I2 and separated by a distance d is given by:

F = μ_0 * I1 * I2 / (2 * π * d)

where μ_0 is the permeability of free space (4π x 10^-7 T m/A).

Rearranging this equation to solve for d, we get:

d = μ_0 * I1 * I2 / (2 * π * F)

Substituting the given values, we get:

d = 4π x 10^-7 T m/A x 400 A x 5.00 A / (2 x π x 4.00 x 10^-3 N/m)

≈ 0.05 m

Therefore, the wires are separated by approximately 0.05 m.

(b) The direction of the currents in the wires can be determined using the right-hand rule for magnetic fields. If we point the thumb of our right hand in the direction of the current in one wire, and the fingers in the direction of the current in the other wire, the force will be in the direction of the palm of our hand.

Since the force is attractive, we know that the currents must be in opposite directions. Therefore, the current in the wire carrying 400 A is in the opposite direction to the current in the wire carrying 5.00 A.

5. A 2.50-m segment of wire supplying current to the motor of a submerged submarine carries 1000 A and feels a 4.00-N repulsive force from a parallel wire 5.00 cm away. What is the direction and magnitude of the current in the other wire?

The force per meter between two parallel wires carrying current I1 and I2 and separated by a distance d is given by:

F = μ_0 x I1 x I2 / (2 x π x d)

where μ_0 is the permeability of free space ($4\pi \times 10^{-7}$ T m/A).

Rearranging this equation to solve for I2, we get:

$I2 = 2 \times \pi \times d \times F / (\mu_0 \times I1)$

Substituting the given values, we get:

$I2 = 2 \times \pi \times 0.05 \text{ m} \times 4.00 \text{ N} / (4\pi \times 10^{-7} \text{ T m/A} \times 1000 \text{ A})$

≈ 0.01 A

Therefore, the current in the other wire is approximately 0.01 A.

To determine the direction of the current in the other wire, we can use the right-hand rule for magnetic fields. If we point the thumb of our right hand in the direction of the current in the wire carrying 1000 A, and the fingers in the direction of the repulsive force, the direction of the palm of our hand will be the direction of the current in the other wire. Since the force is repulsive, the currents must be in the same direction. Therefore, the current in the other wire is also in the same direction as the current in the wire carrying 1000 A.