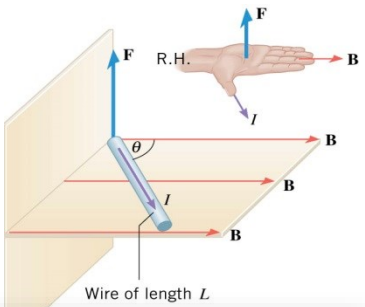
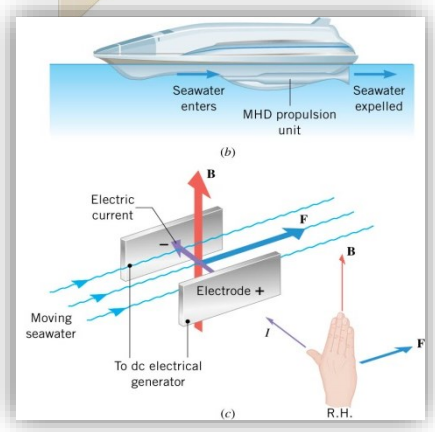
Physics 09-03 Magnetic Force on a Current-Carrying Wire **Name:** _____

Force on a Current-Carrying Wire in B-field



- Direction Follows _____
- $F = ILB \sin\theta$

A 2 m wire is in a 2×10^{-6} T magnetic field pointing into the page. It carries 2 A of current flowing up. What is the force on the wire?



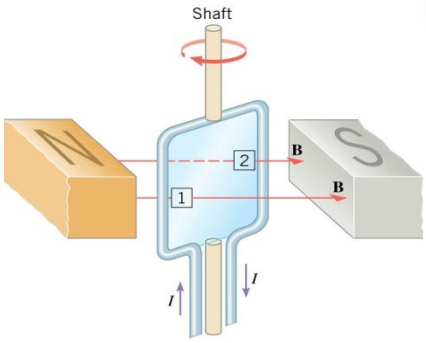
Magnetohydrodynamic Propulsion

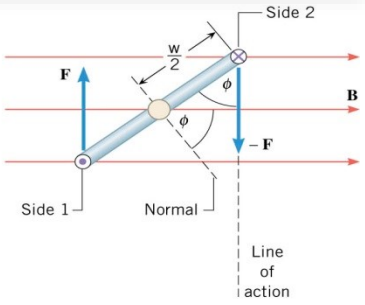
- Way to _____ boats with _____ moving parts
- _____ enters tube under ship
- In the tube are electrodes that run _____ through the water
- Also in the tube is a strong _____ field created by _____
- The interaction with the electric _____ and _____ push the _____ out the back of the tube which pushes boat forward
- $F = ILB\ sin\ \theta$

Torque on a Current Loop in B-field

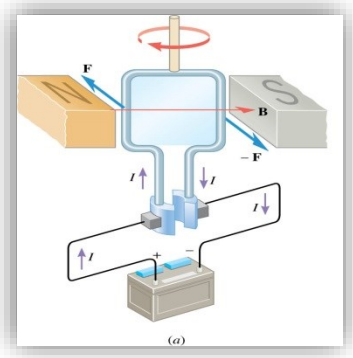
What happens when you put a loop of wire in a magnetic field?

- Side 1 is forced _____ and side 2 is forced _____ (RHR)
- This produces a _____
- The loop turns until its normal is _____ with the B-field
- Torque on Loop of Wire
  - $\tau = NIAB \sin\phi$
    - Where N = Number of loops, I = Current, A = Area of loop, B = Magnetic Field, ϕ = Angle between normal and B-field
  - NIA = Magnetic _____
    - Magnetic _____ ↑, torque ↑





A simple electric motor needs to supply a maximum torque of 10 Nm. It uses 0.1 A of current. The magnetic field in the motor is 0.02 T. If the coil is a circle with radius of 2 cm, how many turns should be in the coil?



Electric Motor

- Many loops of _____-carrying wire placed between two _____ (B-field)
- The loops are attached to _____
- The _____ turns the _____ until the normal is _____ to B-field
- At that point the half-rings _____ connect to electric _____
- _____ makes the loop turn more
- The half-rings _____ with the current to _____ the process

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Practice Work

1. Why would a magnetohydrodynamic drive work better in ocean water than in fresh water? Also, why would superconducting magnets be desirable?
2. Which is more likely to interfere with compass readings, AC current in your refrigerator or DC current when you start your car? Explain.
3. What is the direction of the magnetic force on the current in each of the six cases in Figure 1? (OpenStax 22.31) **left, into, up, no, right, down**
4. What is the direction of a current that experiences the magnetic force shown in each of the three cases in Figure 2, assuming the current runs perpendicular to *B*? (OpenStax 22.32) **left, out, up**
5. (a) What is the force per meter on a lightning bolt at the equator that carries 20,000 A perpendicular to the Earth's 3.00×10^{-5}-T field? (b) What is the direction of the force if the current is straight up and the Earth's field direction is due north, parallel to the ground? (OpenStax 22.34) **0.600 N/m, West**

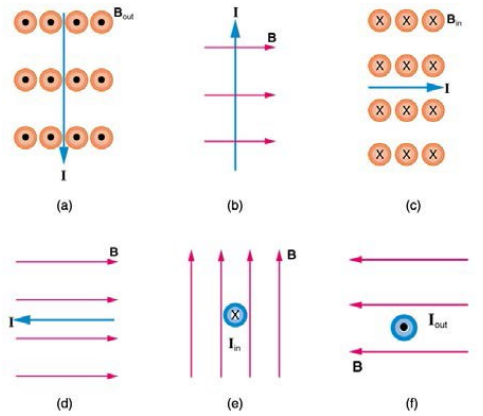

Figure 1

6. (a) A DC power line for a light-rail system carries 1000 A at an angle of 30.0° to the Earth's 5.00×10^{-5}-T field. What is the force on a 100-m section of this line? (b) Discuss practical concerns this presents, if any. (OpenStax 22.35) **2.50 N, must attach them**
7. What force is exerted on the water in an MHD drive utilizing a 25.0-cm-diameter tube, if 100-A current is passed across the tube that is perpendicular to a 2.00-T magnetic field? (The relatively small size of this force indicates the need for very large currents and magnetic fields to make practical MHD drives.) (OpenStax 22.36) **50.0 N**

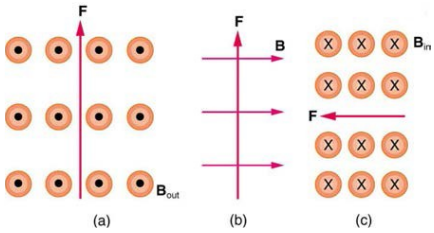

Figure 2

8. A wire carrying a 30.0-A current passes between the poles of a strong magnet that is perpendicular to its field and experiences a 2.16-N force on the 4.00 cm of wire in the field. What is the average field strength? (OpenStax 22.37) **1.80 T**
9. (a) What is the maximum torque on a 150-turn square loop of wire 18.0 cm on a side that carries a 50.0-A current in a 1.60-T field? (b) What is the torque when ϕ is 10.9°? (OpenStax 22.42) **389 Nm, 73.5 Nm**
10. Find the current through a loop needed to create a maximum torque of 9.00 N·m. The loop has 50 square turns that are 15.0 cm on a side and is in a uniform 0.800-T magnetic field. (OpenStax 22.43) **10.0 A**
11. Calculate the magnetic field strength needed on a 200-turn square loop 20.0 cm on a side to create a maximum torque of 300 N·m if the loop is carrying 25.0 A. (OpenStax 22.44) **1.50 T**
12. A proton has a magnetic field due to its spin on its axis. The field is similar to that created by a circular current loop 0.650×10^{-15} m in radius with a current of 1.05×10^{4} A (no kidding). Find the maximum torque on a proton in a 2.50-T field. (This is a significant torque on a small particle.) (OpenStax 22.47) $\mathbf{3.48 \times 10^{-26}}$ **Nm**