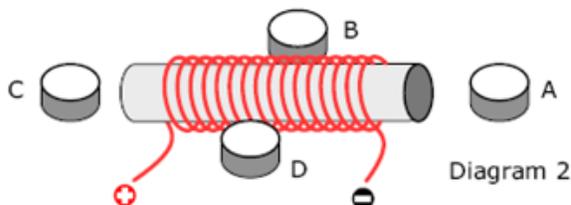
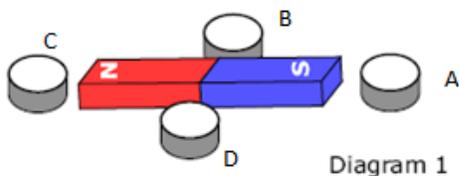




Magnetic Fields:

1. Define a “force field.” You could even reference Star Wars as you explain this.
2. There are two other phenomena that have force fields, besides magnetism (HINT: you’ve studied them both in this course). Compare their equations, directions, and the main components affecting their strength.
3. What is the difference between permanent magnets and electromagnets? Provide details and examples of each.
4. What causes a magnetic field in an electromagnet and a bar magnet? Describe how they are both; ultimately, caused by the same thing (some Internet research may be required).
5. Sketch the current and field lines surrounding the following magnets. Draw arrows on the compasses to show which way they’d be pointing.

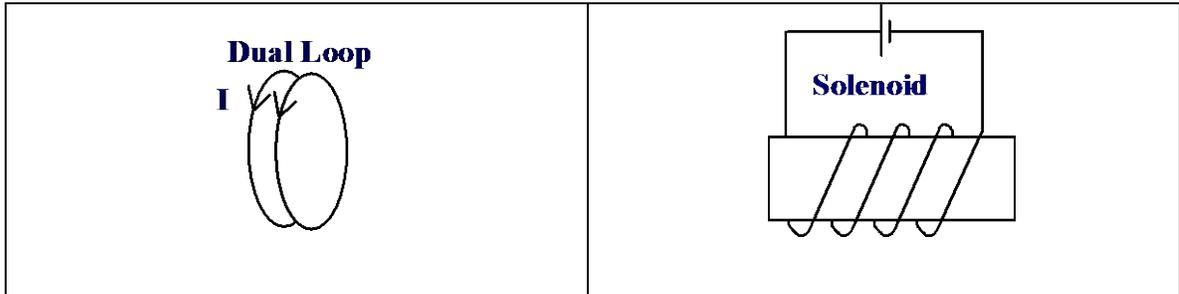


6. Complete the diagrams below by adding in the compass arrows based on the one compass given. Then determine which end of the wire is positive and which must be negative (label)

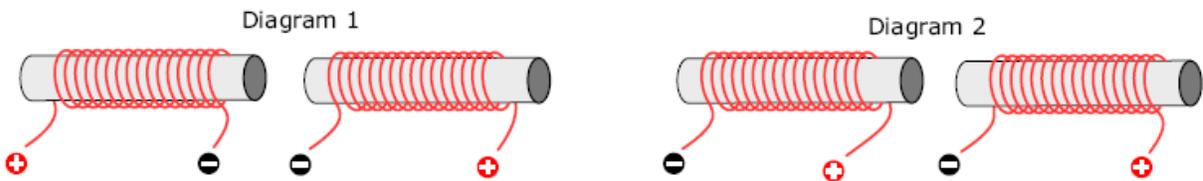


7. Describe the RHR (right-hand-rule) using a sketch and comments, for both a single wire and a solenoid.

8. Draw the magnetic field, using arrows to indicate the direction of the magnetic field.



9. Using your knowledge of magnetism and the right hand rule, determine whether the solenoids (coils) will attract or repel each other. Be sure to draw in the field lines and label the North and South poles.



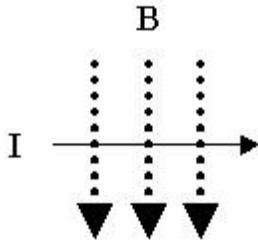
10. Something that people sometimes find confusing about the RHR is deciding which way to point their thumb. If the electrons are going in one direction, the current is in the \_\_\_\_\_ direction. If it's a positive charge that's moving (less common, but possible), then the current goes in the \_\_\_\_\_ direction.
11. Use Ampere's Law for a long, straight conductor (a wire),  $B = \mu_o I / (2\pi d)$ , to calculate  $B$  at a distance of 2.0 cm from a wire carrying a current of 24 A. ( $\mu_o = 4\pi \times 10^{-7}$  Tm/A)
12. For a long straight wire, if the current is halved and the distance from the wire is doubled, what will  $B$  be then?
13. Use Ampere's Law for solenoids to calculate the value of  $B$  inside. The solenoid has 600 turns, a length of 15 cm, and is carrying a current of 5.0 A.
14. The same solenoid is pulled from either end, like a slinky, so that its coils move further apart. If the new density of turns is  $n = 10$  turns/cm, how long is this stretched solenoid? What will the new  $B$ -field become?
15. There are two versions of the equation used to find the magnetic field inside a solenoid. One is  $B = \mu_o NI / L$  while the other is  $B = \mu_o nI$ .
- a. What, precisely, is the difference between  $N$  and  $n$ ?

- b. Explain the relationship between the length,  $L$  of the solenoid and  $B$  using  $B = \mu_0 NI/L$  .  
Describe how this still agrees with  $B = \mu_0 nI$ .
16. A thin, 10-cm long solenoid has a total of 400 turns of wire and carries a current of 2.0 A.
- a. Calculate the field inside the solenoid, near the center using  $B = \mu_0 NI/L$ .
- b. Calculate the field inside the solenoid, near the center using  $B = \mu_0 nI$ .

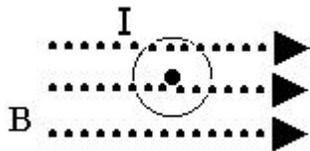
*Magnetic Forces:*

1. A charged particle needs to be \_\_\_\_\_ to create a magnetic field.
2. What are the two common ways to deflect a charged particle? Briefly describe them and ensure you identify which one of them requires movement?
3. Describe the RHR for a moving charged particle in a magnetic field. Use sketches and comments.

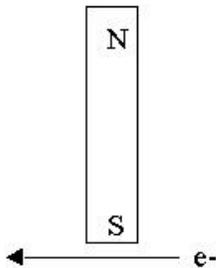
4. A current-carrying wire is immersed in a downward magnetic field, B, as shown. Which way will the wire bend?



5. A current-carrying wire is directed out of the page in a left to right external B-field as shown. Determine the direction of the force.



6. An electron is directed to the left while passing below the South Pole of a magnet as shown below. In what direction will the electron be deflected?



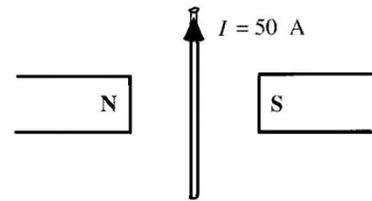
7. A proton is traveling with a velocity directed out of the page and deflected by the North Pole of a magnet situated as shown below. What is the direction of the force that causes the proton to deflect?



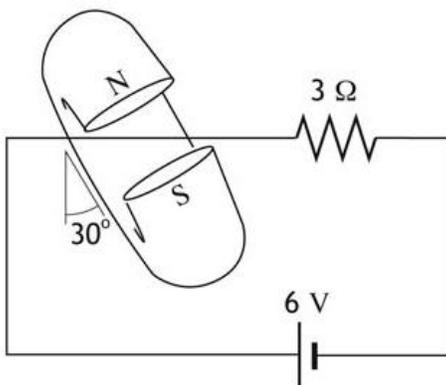
8. An electron moving with a speed of  $0.10 c$  moves through a magnetic field of strength  $0.60 \text{ T}$ . What force acts on the electron?

9. A segment of conducting wire  $5.0 \text{ cm}$  long carrying  $5.0 \text{ A}$  of current is perpendicular to a magnetic field of  $12 \text{ T}$ . What magnetic force acts on the segment?

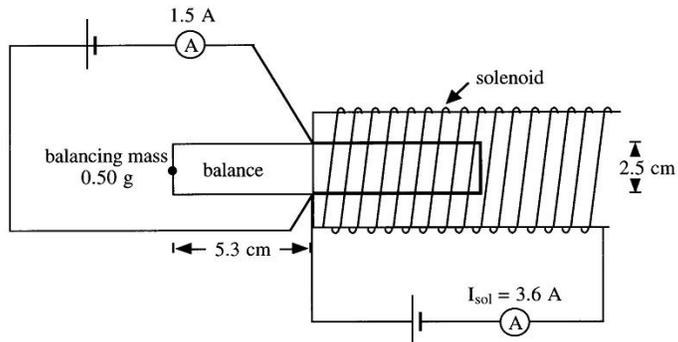
10. A wire carrying  $50 \text{ A}$  of current has a  $0.12 \text{ m}$  length between the poles of a  $0.90 \text{ T}$  magnet, as in the above figure. What force is exerted on the wire (include direction)?



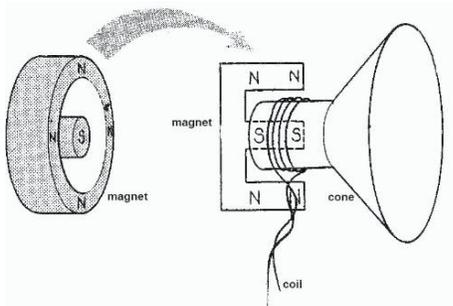
11. A segment of current-carrying wire passes through a uniform magnetic field of  $100 \text{ T}$  at the angle pictured below. What is the force present on the  $1 \text{ cm}$  segment of wire immersed in the B-field? What is the direction of this force?



12. What is the magnetic field  $B$  inside the solenoid of this current balance, if the force of gravity on the 0.50 gram mass just provides enough torque to balance the torque due to the magnetic force on the current balance?

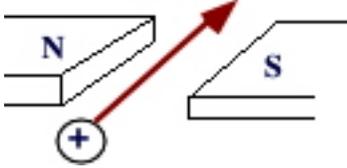
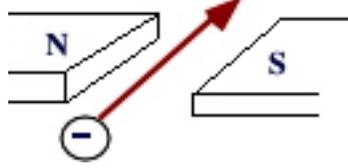
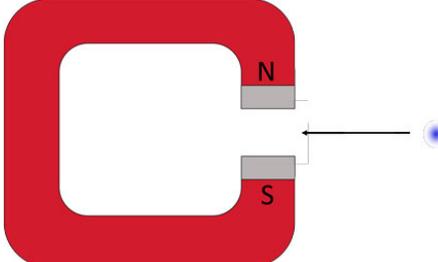
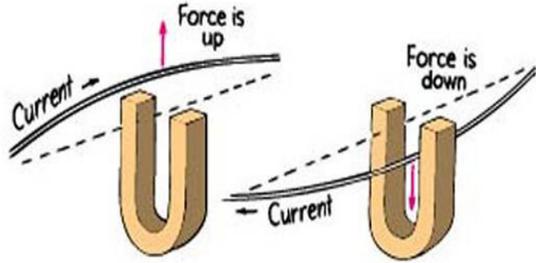


13. A loud-speaker consists of a cone attached to a current-carrying coil located in a magnetic field. Describe exactly how this system works to deliver sound of a particular frequency (matching the music). Be sure to clearly discuss how the force is generated.



14. Two parallel wires each carrying currents in the same direction. Draw a sketch showing the direction of forces on each wire. What if the currents were in opposite directions?

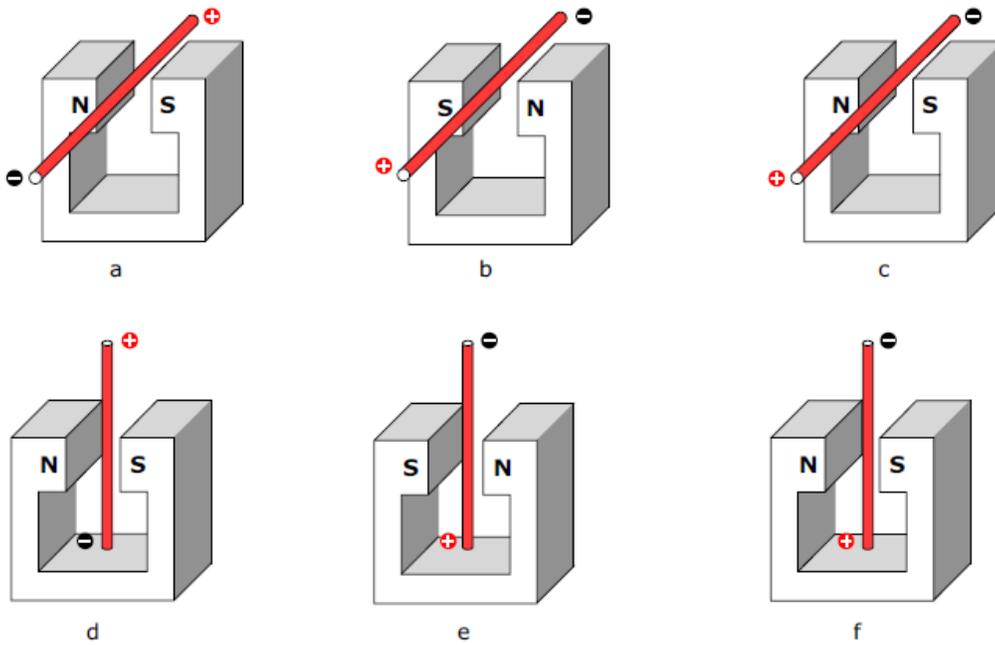
15. Use the right-hand rule to determine the direction of the force on the charges moving in the magnetic fields below.

 <p>The force is _____</p>	 <p>The force is _____</p>
 <p>The proton will be deflected _____</p>	 <p>Label the poles of the horseshoe magnet to reflect what is happening.</p>

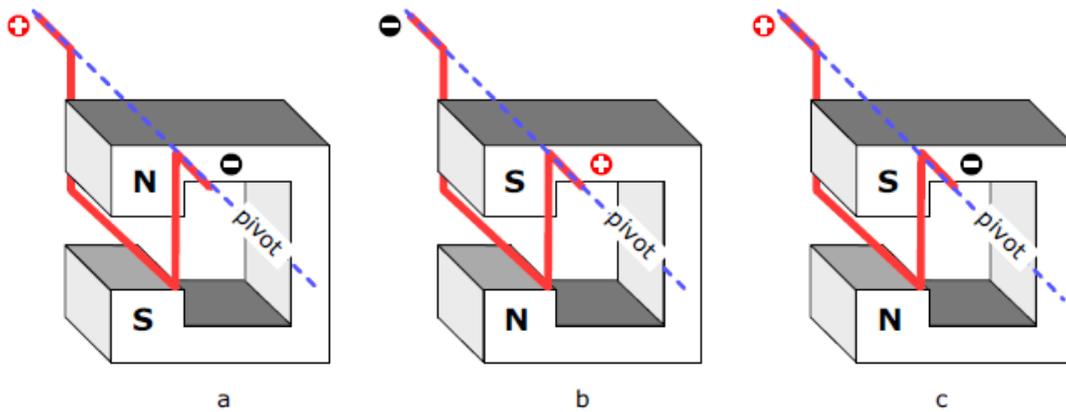
16. A beam of electrons passes through a magnetic field without being deflected. What can you conclude about the orientation of the beam relative to the magnetic field? Sketch a diagram showing the B-field and the electron beam.

17. A magnet can exert a force on a moving charged particle, but it cannot do work on it (changing its kinetic energy). Why not? (a diagram might help).

18. Draw the arrow on the conductor to show which way it will move when the current flows as indicated.



19. In which direction will the pivoted wire swing when the current flows as shown?



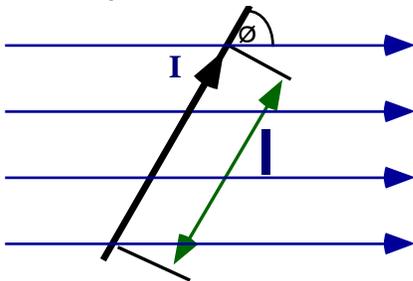
20. Derive  $F = BIL$  by starting with a single charge formula  $F = qvB$  and recognizing that current is simply  $I = Q/t$ .

21. The formula that relates the magnetic force acting on a moving charge is given by  $F = qvB$  while a wire in a magnetic field is  $F = BIL$ . Describe each variable including appropriate units and indicate what variables must be perpendicular to create a force.

$F = qvB$	$F = BIL$
$F =$	$F =$
$B =$	$B =$
$q =$	$I =$
$v =$	$L =$
What must be perpendicular?	What must be perpendicular?

22. An electron travels with a speed of  $2.60 \times 10^6$  m/s in a magnetic field of 0.30 T. What is the magnitude of the force exerted on the electron?

23. A 12 cm length of wire carrying a 30 A current is positioned between the pole faces of a magnet at an angle of  $\theta = 60^\circ$  as shown below. The magnetic field is approximately uniform at 0.90 T. What is the magnitude of the force on the wire?



24. A magnetic field is perpendicular to an electric field.
- What velocity does an electron need to have in order to travel straight through the crossed E and B fields, given that  $E = 1.0 \times 10^5$  N/C and  $B = 0.40$  T?

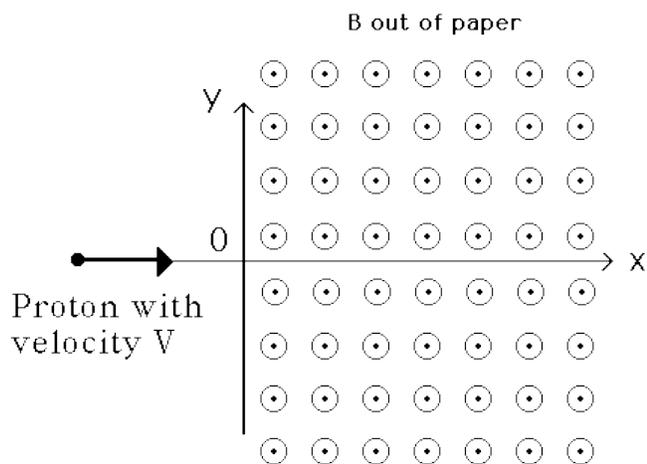
- b. What electric field is needed to balance the effects of an electron traveling with velocity  $3.0 \times 10^5$  m/s through a magnetic field 0.5 T in strength?
- c. What magnetic field is needed to balance the effects of an electron traveling with velocity  $8.0 \times 10^5$  m/s through an electric field of  $4.0 \times 10^5$  N/C?
- d. If the mass of the electron above were to magically double, what affect would it have on your answers above? Support with equation(s).

Mass Spectrometer:

1. Moving charges generate their own \_\_\_\_\_ .
2. The magnetic force on a charged particle is always \_\_\_\_\_ to the velocity of the particle. This creates a situation like a car moving in a circular track, where the friction force pushes the car towards the \_\_\_\_\_ of the circle.
3. A way to make the circular motion of the particle tighter (smaller circle) is to \_\_\_\_\_ the magnetic field.
4. What is the speed of a proton that travels in a circular path of radius 0.045 cm, perpendicular to a 3.0 T magnetic field?
5. An electron traveling at speed  $v$  enters a magnetic field of strength  $B$ , and is forced into a circular path of radius  $R$ . If the strength of the field is doubled, and the speed of the electron is also doubled, what will the radius of the circular path become?

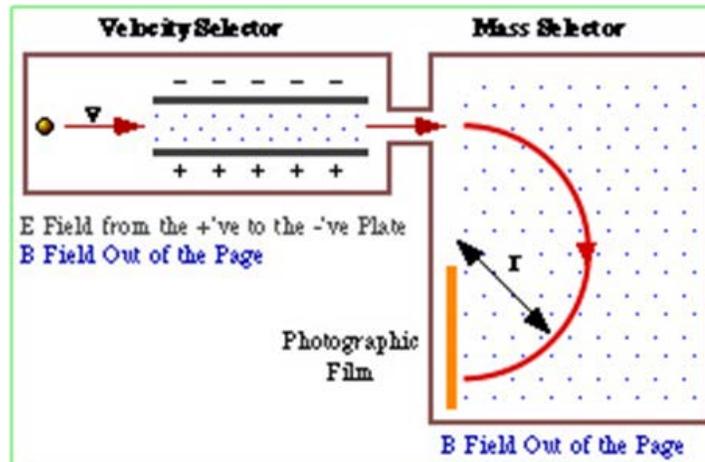
6. In the velocity selector part of a mass spectrometer, a field of 0.65 T is used for magnetic deflection of a beam of protons travelling at a speed of  $1.0 \times 10^6$  m/s. What electric field is needed to balance the force due to the magnetic field? If the distance between the plates of the electrical deflection apparatus is 0.50 cm, what voltage must be applied to the plates?
7. What speed must electrons in a beam of electrons going through a velocity selector have, if the beam is not deflected by crossed electric and magnetic fields of strengths  $6.0 \times 10^3$  V/m and 0.0030 T respectively? If the electric field is shut off, what would the radius of the beam become due to the unbalanced magnetic force?

8. A proton is accelerated through a potential difference of 10 000V and then enters a uniform magnetic field as shown below.



- a. Sketch the path that the proton will follow. How much work is done on the proton once it enters the field?
- b. If the strength of the B-field is 0.2T, what is the radius of the path? (ans: 7.2 cm)

9. Consider the mass spectrometer shown schematically. The electric field between the plates of the velocity selector is **950 V/m**, and the magnetic fields in both the velocity selector and the deflection chamber have magnitudes of **0.930 T**. Calculate the radius of the path in the system for a singly charged ion with mass  $m = 2.18 \times 10^{-26}$  kg.



- The B-field in the velocity selector is out of the page (as indicated by dots). What is the direction of the electric field? Draw in a few field lines onto the diagram above.
- Use your right-hand rule to determine the direction of the magnetic force acting on the moving charge assuming that it is positively charged? What is the direction of the electric force due to the electric field? To answer this question draw the free-body diagram for this positive charge while inside the velocity selector. Label  $F_B$  and  $F_E$  onto the diagram.
- In order for the charge to remain moving in a straight path in the velocity selector, what must be true?
- What if it were a negatively charged ion. Draw the free-body diagram below. Will a negatively charged ion behave any differently?

- e. Determine the velocity that the ion must have to emerge from the velocity selector undeflected. Show why a negatively charged ion will have the same speed based on the equation you used. What if it were “doubly charged”? (ans: 1022 m/s)
- f. Describe how the magnetic force is oriented relative to a positive ions speed,  $v$  once it enters the deflecting chamber. A diagram would be sufficient.
- g. Determine the equation of motion for the ion in the deflecting chamber and use it to solve for the radius of the path.
- h. What affect would doubling the mass and tripling the charge have on the final radius? Use equation to prove your answer.

Answers:

Magnetic Fields

2) gravity, electrical, magnetic 5) Diagram1: A: left B:right C:left D:right Diagram2: A: right B:left C:right D:left 6) left-to-right: neg, pos, neutral, neutral 8) left-to-right: S,N,N,S  
 9) left-to-right: S,N,S,N,S,N,N,S,attract,repel 10) opposite,same 11)  $2.4 \times 10^{-4} \text{ T}$  12) one-fourth  
 13)  $2.5 \times 10^{-2} \text{ T}$  14) 60cm,one-fourth 16)  $1.0 \times 10^{-2} \text{ T}$

Magnetic Forces

1) moving 2) electrical field, magnetic field 4) into-page 5) upwards 6) out-of-plate 7) upwards  
 8)  $2.9 \times 10^{-12} \text{ N}$  9)  $3.0 \text{ N}$  10)  $5.4 \text{ N}$  [into page] 11)  $1.73 \text{ N}$  [into page] 12)  $0.13 \text{ T}$  14)  $8.5 \times 10^{-3} \text{ N}$  15)  
 top row: down, up; bottom row: out,S,N,S,N 16) parallel 17) perpendicular 18) top row: up,up,down;  
 bottom row: out,out,in 19) right,right,left 20)  $F = l\ell B$  22)  $1.25 \times 10^{-13} \text{ N}$  23)  $2.8 \text{ N}$   
 24) a)  $2.5 \times 10^5 \text{ m/s}$  b)  $1.5 \times 10^5 \text{ N/C}$  c)  $0.5 \text{ T}$  d) no change

Mass Spectrometer

1) magnetic field 2) perpendicular,centre 3) increase 4)  $1.3 \times 10^5 \text{ m/s}$  5) same radius  
 6)  $6.5 \times 10^5 \text{ V/m}$ ,  $3.3 \times 10^3 \text{ V}$  7)  $2.0 \times 10^6 \text{ m/s}$ , 3.8 mm 8) a) circle down b) 7.2cm  
 9) a) up b)  $F_B = \text{down}, F_E = \text{up}$  c)  $F_E = F_B, v = E/B$  d)  $F_B = \text{up}, F_E = \text{down}$  e) 1022m/s f) perpendicular  
 g)  $1.50 \times 10^{-4} \text{ m}$  h) 2/3