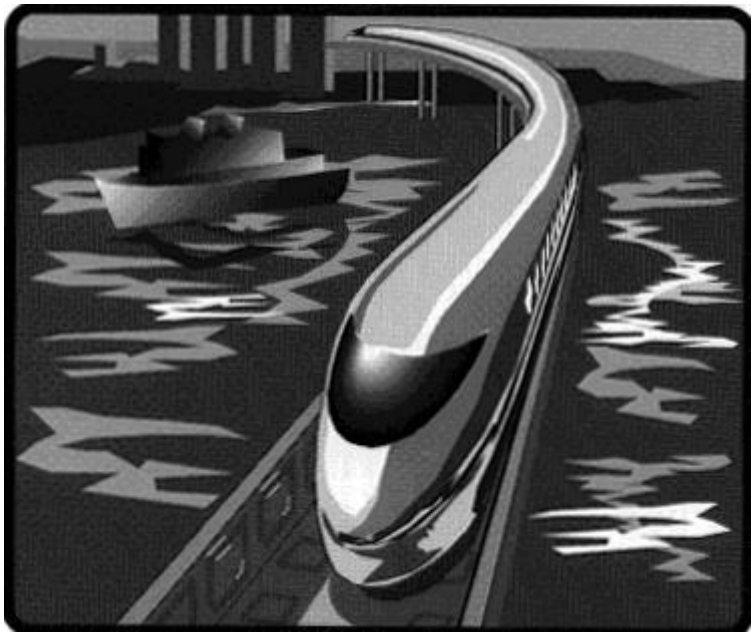
# Magnetic Levitation



Team #_____ School_____

Names_____

Instructions: This test is three sections. Multiple choice, short answer, and problem solving. Choose the best answer for each multiple choice question. Short answer is rather self-explanatory. And be sure to show your work on the problem. NO WORK=NO POINTS. Oh, and remember your sig figs...you'll lose half a point for EVERY sig fig error.

There is an answer sheet for the multiple choice on the back of this cover page. Only answers written there will be scored. The next two sheets contain the short answer and problem. Write directly on those. You may take the test apart.

You will be called up one at a time to run your MagLev. You may work on this test the whole period, whenever you are not running your cart.

I congratulate you on finishing reading these rules. Good luck!

Team #_____

Answer Sheet:

1. _____
2. _____
3. _____
4. _____
5. _____
6. _____
7. _____
8. _____
9. _____
10. _____
11. _____
12. _____
13. _____
14. _____
15. _____
16. _____
17. _____
18. _____
19. _____
20. _____
21. _____
22. _____
23. _____
24. _____
25. _____

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Short Answer/ Fill in the blank (20 points):

1. A conductor is poised in a magnetic field produced by a north poled on the left and a south pole on the right. What is the direction of the induced emf when a) the conductor moves down through the field and b) the field moves down across the conductor?

2. If a charged particle is circulating in a magnetic field and it reflects back and forth between two ends of the field, it is said to be trapped in a(n) _____.

3. Briefly describe how a cyclotron works and mention one inherent problem with its operation.

4. What is an electrodynamic tether and how can it be used to generate electricity?

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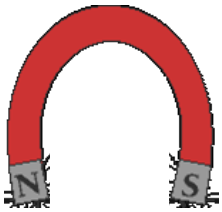
5. Why are rare earth magnets so much stronger than standard ferrite magnets?

6. Sketch magnetic field lines for the following systems (at least 8 of them per diagram). The horseshoe magnetic is weaker than the bar magnet.

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Problem (30 points): Show all work to get credit.

A square loop of wire with a perimeter of 1.00 m is placed in a magnetic field of strength 10.0 T so that it is parallel to the magnetic field. The loop is then rotated at a rate of one revolution per minute.

a) What is the flux through the loop at its starting point?

b) What is the maximum flux through the loop?

c) Sketch a graph of flux versus time for the first minute and complete the following chart. Clearly label points of maximum and minimum flux.

| Time (min) | 0 | 0.125 | 0.300 | 0.500 | 0.625 | 0.750 | 1.00 |
|---|---|---|---|---|---|---|---|
| Flux (Wb) | | | | | | | |

d) What kind of curve is this? Explain the behavior of the curve after 0.500 minutes.

e) Using the data points from your chart above, estimate the induced emf at the following times. Note: this does not require calculus, but an exact answer can be given using it and will be accepted.

| Time (min) | 0.0625 | 0.213 | 0.400 | 0.563 | 0.688 | 0.875 |
|---|---|---|---|---|---|---|
| Flux (Wb) | | | | | | |

f) Write an equation for flux as a function of time in seconds (use radians).

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Multiple Choice (50 points):

1. The experiment that shows the connection between an electric current and magnetism was first performed by
   a. Gilbert
   b. Van Allen
   c. Gauss
   d. Oersted

2. A line drawn through points on the earth's surface where the dipping needle is horizontal is the
   a. Declination
   b. "electromagnetic tether"
   c. Equator
   d. Polar line

3. An important law regarding induced currents states that they are in such a direction that opposes the change that induced it. This is a statement of
   a. Conservation of charge
   b. Conservation of matter
   c. Conservation of momentum
   d. Conservation of energy

4. *No* current is induced in a conducting loop when the conductor
   a. moves down through a magnetic field
   b. experiences a change in flux linkage
   c. move parallel to the magnetic field
   d. cuts through lines of magnetic flux

5. The force between two magnetic poles is directly proportional to
   a. the size of the poles
   b. product of the strengths of the poles
   c. distance between them
   d. square of the distance between them

6. The force experienced by each of two long, straight, and parallel wires of length $L$ separated by a distance $d$ and carrying currents $I_1$ and $I_2$ is proportional to
   a. $L\ I_1\ I_2\ d$
   b. $L\ I_1\ I_2 /d$
   c. $L /(I_1\ I_2\ d)$
   d. $L/ \mathrm{l}\ I_1\ I_2\ d$

7. A proton moving eastward with a velocity of $7 \times 10^3$ m/s enters a magnetic field of 0.2 T pointing northward. What is the magnitude and direction of the force that acts on the proton?
   a. 0 N
   b. $2.2 \times 10^{-16}$ N perpendicular out with respect to Earth's north
   c. $1.1 \times 10^{-16}$ N eastwards
   d. $4.4 \times 10^{-16}$ N westwards

8. If the number of turns in a rectangular coil of wire that is rotating in a magnetic field is doubled, what happens to the induced emf assuming all other variables stay constant.

a. Nothing
b. Reduced by a factor of 2
c. Doubled
d. Quadrupled

9. A bar magnet is placed with its north pole pointing towards a coil of wire that has a cross-sectional area of 0.020 $m^2$ and 6 turns. What is the magnitude of the induced emf?

a. 0.04 V
b. 0.01 V
c. 0.02 V
d. 0 V

10. An electron, moving west, enters a magnetic field of a certain strength. Because of this magnetic field, the proton curves upward. What is the direction of the magnetic field?

a. Towards the north
b. Towards the south
c. Upward
d. Towards the west

11. The technology for Superconducting Maglev Transportation was developed by

a. Alfred Zehden
b. James R. Powell
c. Eric Laithwaite
d. Nikola Tesla (theorized but did not develop the technology)

12. A proton in a magnetic field does not experience a force. Which of the following statements may be true?

I. The proton has zero velocity
II. The proton has a nonzero velocity
III. The proton is moving parallel to the direction of the magnetic field

a. I only
b. II only
c. III only
d. I and III
e. I, II, and III

13. A square coil of length *L* and is placed in a magnetic field *B*. If there is a current *I* flowing through this coil, what is the force acting on one side of the coil?

a. $IL\,B\sin\theta$
b. $IL\,B$
c. 0
d. $IL\,B/2$

14. A bar magnet is placed with its north pole pointing toward a coil of wire with a cross-sectional area 0.020 $m^2$. If the rate of change in the strength of the magnetic field is .040 T/s, what is the magnitude of the induced emf?

a. $5.6\text{x}10^{-1}$ V
b. $5.6\text{x}10^{-2}$ V
c. $5.6\text{x}10^{-3}$ V
d. $5.6\text{x}10^{-4}$ V

15. Pretend a loop of wire is lying on the plane of this page. A magnet is being thrust into it. What is the direction of induced current?

a. Clockwise
b. Counterclockwise
c. There is no current
d. How am I supposed to know?

16. An electron moving in a region of space experiences no acceleration. Which of the following may be correct?

a. The electric field and magnetic field are in the same direction
b. The electric field and magnetic field are perpendicular
c. There is an electric field but no magnetic field
d. There is a magnetic field but no electric field

17. Two long, parallel wires carry currents of different magnitudes. If the magnitude of the larger current is doubled while the magnitude of the smaller current is halved, what happens to the magnitude of the force between the wires?

a. Quadruples
b. Doubles
c. Nothing
d. You need the magnitudes

18. Inside a solenoid of 10 turns with a current of 3 A, what is the magnetic field?

a. $(10/3)\mu_0$
b. $30\mu_0$
c. $(20/3)\mu_0$
d. $60\mu_0$

19. A long wire of radius R carrying current I is placed along the y-axis. At what distance *x* measured from the center of the wire is the magnetic field a maximum?

a. R
b. R/2
c. R/4
d. 0

20. An irregularly shaped coil is lying flat on a horizontal surface. A bar magnet is being held over the coil with its south pole facing down. What is the direction of the induced current?

a. Clockwise
b. Counterclockwise
c. There is no current
d. Actually, electrons are flying out into space, so no one direction is correct

21. The number of turns in the coil of a generator is reduced by a factor of 2 and at the same time is rotated twice as fast while all other factors are constant. What is the effect on emf?

a. It is reduced by a factor of 4
b. It is doubled
c. Nothing
d. It is quadrupled

22. Which of the following is a Superconducting Maglev line?

a. Chuo Shinkansen
b. Amtrak Skyline
c. Tishieutin Rail Transportation
d. TEDA

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23. What we call the geographic north pole is
    a. The magnetic north pole
    b. The magnetic south pole
    c. Santa's house
    d. None of the above

24. Which of the following scientists did NOT contribute to the understanding of magnetism and its relation to electricity?
    a. James Clerk Maxwell
    b. Oliver Heaviside
    c. Heinrich Rudolph Hertz
    d. Luigi Galvani

24. The Tesla is also known as the
    a. (Volt x second)/(meter)^2
    b. (Weber)/(meter)
    c. (Newton)/(Coulomb x meter)
    d. (kilogram)/(Ampere x second)