

# ULI

## (Universal Lab Interface)

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# User's Manual

## Introduction

MacMotion allows you to make measurements of motion and force using the Macintosh computer. These measurements are displayed graphically on the screen and can be manipulated and saved. MacMotion is a useful tool for instant analysis of complicated data on one-dimensional motions and forces.

In most modern experimental laboratories, electronic sensors are used to collect data automatically. It is possible to attach these sensors to computers—a very powerful capability. Microcomputers, when coupled with the appropriate software packages, are capable of analyzing the signals and instantly displaying them on the screen in easily understood forms. By coupling the collection of real data with a symbolic representation of it in the form of a graph, you can obtain an immediate “real time” picture of the data while it is being collected.

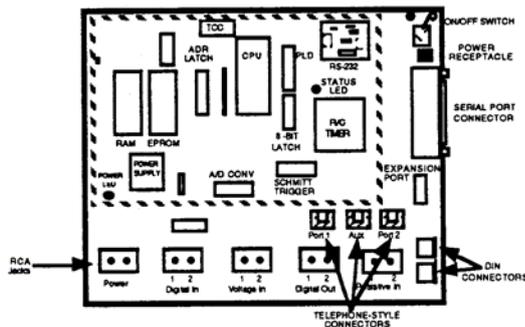
## Required Materials

To use the MacMotion software, you should have the following:

- A Macintosh Plus or newer computer
- A Universal Lab Interface (ULI) with:
  - 9-volt power supply
  - Macintosh modem cable
- Either an Ultrasonic Motion Detector or a force sensor, or both.

All of these items (except the Macintosh computer) are available from Vernier Software, 2920 S.W. 89th St., Portland, Oregon 97225, (503) 297-5317.

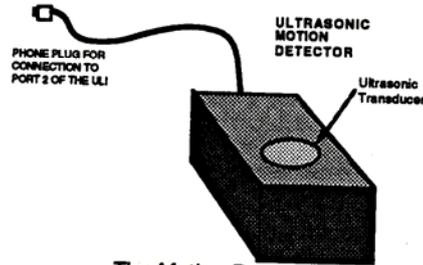
The Universal Laboratory Interface (ULI) can be used with many other sensors, including photogates, radiation detectors, pH probes, and temperature sensors. See *Appendix A* for further details.



The ULI (Top View)

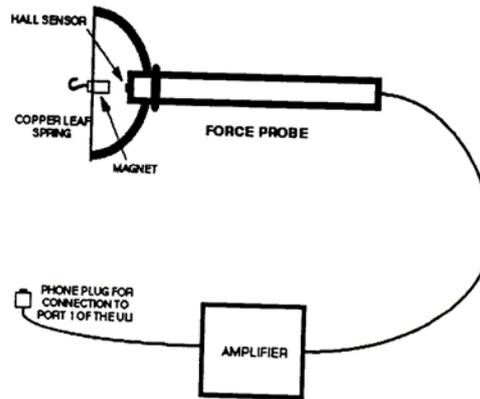
The Ultrasonic Motion Detector (Motion Detector for short) is similar to the automatic range finder on Polaroid cameras. It is a sonar range-finding device that emits ultrasonic pulses and records the length of time it takes for the reflected pulses to return. From this time and the known speed of sound, it calculates a distance.

By using several successive distance measurements, the computer can also calculate velocity and acceleration. The range of the Motion Detector is about 0.45 to 6 meters. *Appendix C* of this manual gives a more detailed explanation of how the Motion Detector works.



*The Motion Detector*

A force sensor determines how much force (either push or pull) is being applied to it and returns this measurement to the ULI and then to the computer. Two different types of force sensors are available for use with MacMotion. The Force Probe (order code U-FP) contains a Hall effect sensor that responds electrically to changes in magnetic field. The moveable portion of the probe has a small permanent magnet attached to it. The force on the probe is determined indirectly by measuring the magnetic field with the Hall sensor.



*The Hall Effect Force Probe*

The other types of force sensors available are based on strain gages. Vernier Software sells an assembled Student Force Sensor (Order Code SFS-DIN) and a Strain Gage Force Transducer Parts Kit (SGK-DIN). See *Appendix D* for a more detailed explanation of how both types of force sensors work and information on how to adjust their sensitivity.

## Initial Setup

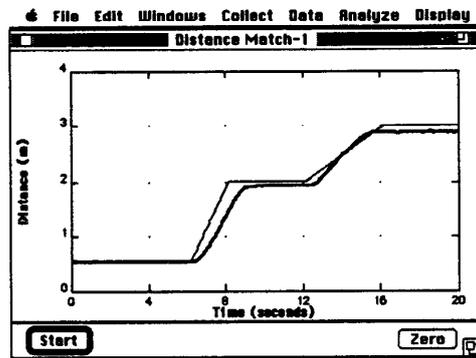
Before turning on your Macintosh computer, you should set up and connect the Universal Lab Interface (ULI) and the detectors. The ULI should be placed on the desktop near the Macintosh. Use

Esempio di raccolta dati



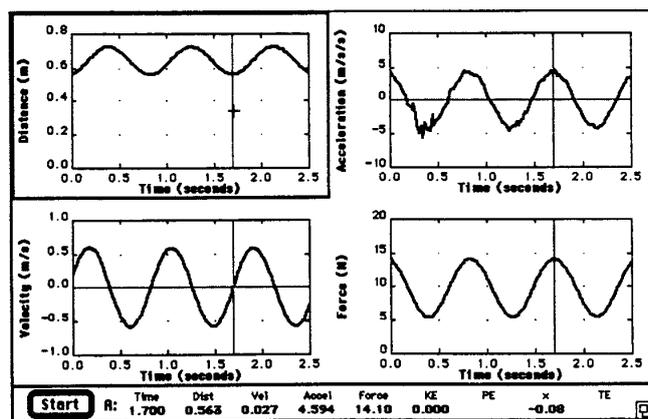
**Files on the Disk**

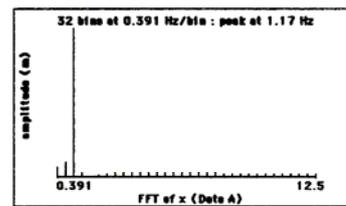
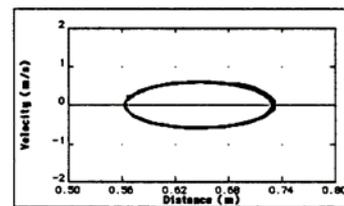
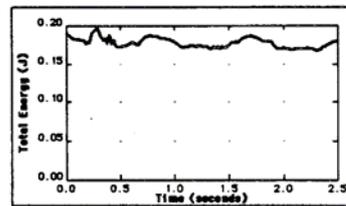
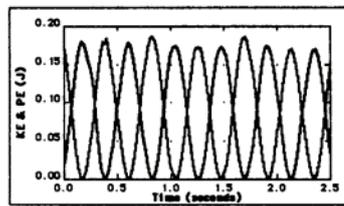
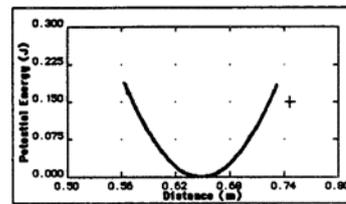
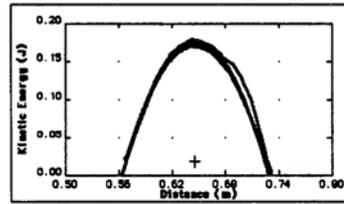
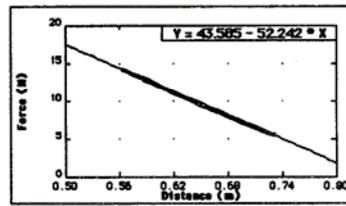
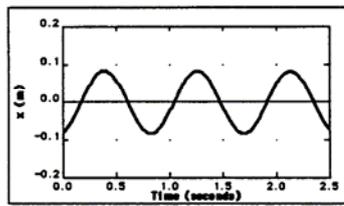
There are several experiments saved on the MacMotion disk that can be used as challenges for students. These files have names such as Constant Acceleration, Constant Velocity, etc. When one of these experiments is opened, Data B will be loaded and graphed. The student should try to match Data B by moving toward or away from the Motion Detector. Student data will be graphed on top of Data B, so comparison is easy. Exercises of this sort are an excellent way to learn about velocity and acceleration. Here is a sample graph made using the file Distance Match. The darker line is the student's attempt at matching the challenge.



**MacMotion in Action**

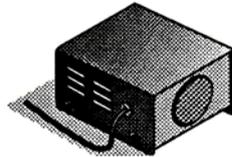
This User's Manual has mentioned only a few of the features of MacMotion. There is a lot more you can do. As an example, take a look at the graphs below. All of the graphs were made of a single run of a simple harmonic motion experiment. A weight was suspended from a spring which was attached to a force sensor. The spring constant was determined by the slope of the linear fit of the force vs. distance graph. This value was used to determine the potential energy. Many of the figures you see in physics textbooks can be produced on the MacMotion screen.





## Appendix C

### How the Motion Detector Works



*Motion Detector*

The Motion Detector measures the distance from itself to the nearest object in front of it. In order to provide information about velocity and acceleration, the Motion Detector makes several measurements, and the computer calculates the values using standard physics equations.

To determine distances, the Motion Detector emits and receives pulses of ultrasound. The frequency of this ultrasound is about 50 KHz. Since the speed of ultrasound at room temperature air is known, the Motion Detector calculates the distance of an object by timing how long the pulse takes to reflect off the object and return to the detector. This is similar to how a bat "sees" using ultrasound. It is also how a Polaroid autofocus camera determines the distance to an object to focus properly.

The ultrasonic sound emitted by the Motion Detector spreads about 15° off axis. Keep this in mind as you design your experiments. The most common problem people have when using the Motion Detector is they are getting unexpected reflections off of a desk, table, or chair in the room. Consider this example: If you have a table two meters out in the room which is a meter off the target line of the Motion Detector, you may assume that it is out of the way. As you start doing experiments, everything works fine, except that if you move several meters away from the Motion Detector, it still reports two meters. It is reporting the distance to the first object that is sending back reflections—the table. If you have problems of this sort, check for an object that might be causing an unexpected reflection. You may be able to solve the problem by draping a cloth over the reflector to minimize reflections. Another trick to try is placing a cloth on the table in front of the Motion Detector to reduce ultrasonic sound waves reflecting off the table and into the transducer.

The Motion Detector does not work for objects closer than 0.45 meters due to ringing of the ultrasonic sending diaphragm. The maximum range is about six meters.

The clicking sound that the Motion Detector makes is not the ultrasound used to determine the distance to an object, but is instead a by-product of the mechanism that produces the ultrasonic sound. Most people cannot hear the frequencies used by the Motion Detector, but if you put your ear near the device, you may be able to "feel" the pressure pulse of the sound against your eardrum.

## Appendix D

### How the Force Sensors Work

#### THE HALL-EFFECT FORCE PROBE



*The Force Probe*

Like the Motion Detector, the Force Probe (Order Code U-FP) actually measures distance. If you examine the probe, you will see a moveable part to the Force Probe—a cylinder embedded in a strip of brass which acts as a leaf spring. This cylinder is a magnet. The field surrounding the magnet is sensed by a Hall effect sensor mounted at the end of the handle of the Force Probe. The Hall effect sensor produces a current that varies linearly with the magnetic field. As the brass sheet that holds the permanent magnet flexes under a push or pull, the magnetic field at the Hall sensor changes. This results in a change in the current flowing through the sensor. The changing current values can be sensed electronically and recorded by the ULI. The current is directly related to the magnetic field, and for small flexures, the brass leaf acts like a Hooke's law spring. Thus the changes in current in the Hall probe are directly related to the force on the leaf spring. The ULI indirectly reads the force and relays the reading on the computer.

The zeroing operation causes the ULI to adjust the amplifier connected to the Force Probe for optimum performance. It also returns a "no-load" reading.

**Note:** It is very important that you not pull on the Force Probe too hard. The brass sheet may be permanently deformed, ruining the effectiveness of the probe.

## Adjusting the Hall-Effect Force Probe's Sensitivity

The sensitivity of the Force Probe can be adjusted by moving the head of the probe (which includes the magnet) relative to the handle. Moving the magnet closer to the Hall effect sensor (built into the end of the handle) makes the Force Probe more sensitive. Moving the magnet further out allows the Force Probe to be used with a wider range of forces. For best results, the raw count should change by 200 or 300 counts for the kind of forces you plan to measure. When the Force Probe is shipped, the distance between the end of the magnet and the Hall effect sensor should be about 6 mm. You can change this distance by a millimeter or two. To give you some idea of how the sensitivity depends upon the spacing, here are the results of tests done with one particular Force Probe:

Spacing	Counts/Newton	Range of Force Probe
6 mm	35	±15 N
2 mm	270	±2 N
10 mm	28	±36 N

To adjust the Force Probe, follow this procedure:

1. Loosen the large brass nut on the Force Probe.
2. Rotate the whole head of the Force Probe to move the magnet closer to or further away from the Hall effect sensor in the end of the handle.
3. Gently tighten the brass nut.
4. Test the Force Probe with the new setting. First zero the Force Probe with no force applied. Make sure that the sensitivity is as you want it. Make sure that the readings do not "limit out" at 0 or 1024 raw counts. If necessary, readjust the position of the head.
5. When you have the sensitivity set as you want it, tighten the brass nut more firmly using only your hands. **Do not use tools.** Remember that the threads used here are plastic and it would be easy to strip them using tools.
6. You may want to calibrate the Force Probe with the new sensitivity setting and save the calibration for later use.

## STRAIN GAGE FORCE SENSORS

A force sensor based on strain gages can also be used with MacMotion. Vernier Software has an assembled version and a parts kit.

**Student Force Sensor** The assembled Student Force Sensor (Order Code SFS-DIN, \$99) uses strain gages to measure force. It plugs into the DIN1 connector of the ULI and reads either pushes or pulls in the range 0.05 to 20 newtons. The strain gages are built into a U-shaped device that can be either hand-held or mounted on a ringstand.

**Strain Gage Kit** Vernier Software also sells a kit for building a strain gage force measurement system (Order Code SGK-DIN, \$30.00). The kit comes with a custom circuit board, two strain gages, and all the electronic components needed. It does not include a box for housing the circuit board or a bar onto which to mount the strain gages. This kit takes time and patience to build, even with the custom circuit board. However, it can be a great student project for learning about strain gages.

## 7.9 L'effetto Hall

Consideriamo una lastra metallica percorsa da una corrente di intensità  $I$ , immersa in un campo magnetico  $\vec{B}$  ad essa perpendicolare, come indicato in fig. 7.8. Questo esercita sulla lastrina e sulle cariche in moto all'interno di essa una forza trasversale  $\vec{F}$ , che, nel caso considerato, è diretta a sinistra rispetto alla corrente.

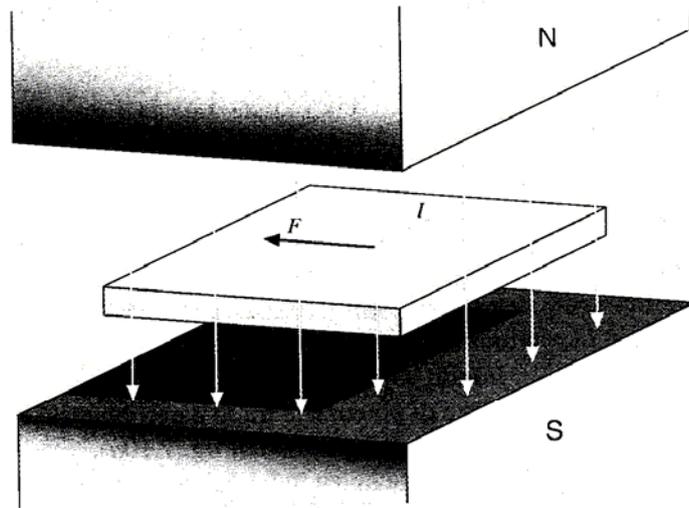


Figura 7.8

Di conseguenza, le cariche elettriche in moto, indipendentemente dal loro segno, tenderanno a spostarsi verso sinistra mentre si muovono nel conduttore e l'accumulo di cariche da una parte della lastra fa sì che si stabilisca una differenza di potenziale  $\Delta V$  tra le pareti laterali. Questa genera un campo elettrico  $\vec{E}$  che tende a richiamare le cariche sul percorso originario, compensando l'azione del campo magnetico e ristabilendo l'equilibrio.

Il fenomeno prende il nome di **effetto Hall**.

Notiamo che il lato ove si accumulano le cariche è sempre lo stesso, comunque venga avvolto o sistemato il conduttore, perché, cambiando la direzione della corrente, cambia anche la direzione della forza (vedi fig. 7.9).

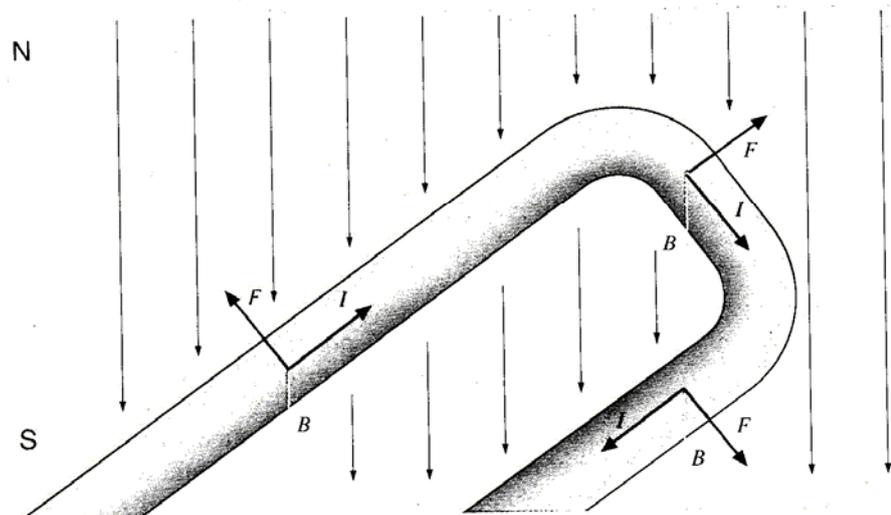


Figura 7.9

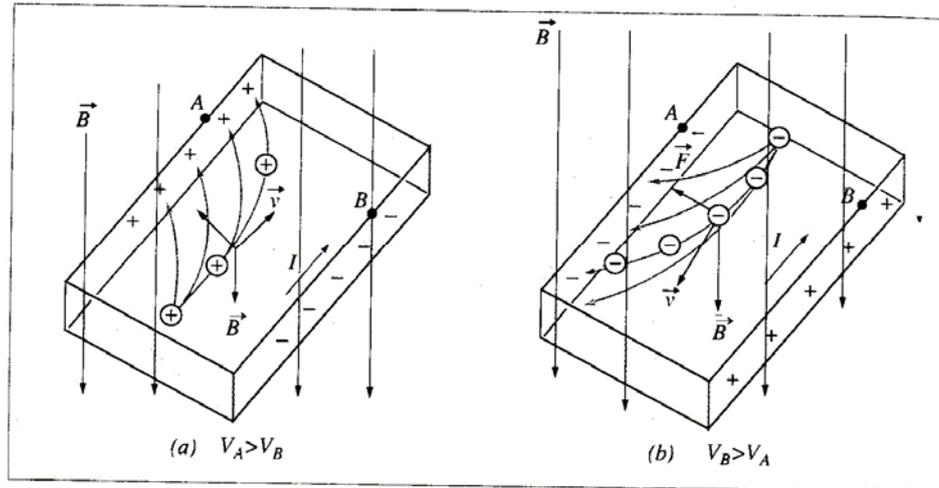


Figura 7.10 Distribuzione delle cariche in moto nel conduttore: (a) se i portatori di carica fossero positivi; (b) se i portatori di carica fossero negativi.

L'effetto Hall ha permesso di stabilire che nei conduttori metallici si muovono cariche negative.

Infatti, se le cariche in moto nel conduttore fossero positive, misurando la differenza di potenziale tra le pareti opposte del conduttore, essendo  $V_A > V_B$ , si troverebbe  $V_A - V_B > 0$  (vedi fig. 7.10a).

Se le cariche in moto fossero negative, si avrebbe la situazione opposta: l'accumularsi delle cariche negative sul lato sinistro porterebbe ad avere  $V_A < V_B$  e quindi  $V_A - V_B < 0$  (vedi fig. 7.10b).

L'esperienza dimostra che nei metalli, in situazione analoga a quella in figura, si ha  $V_A - V_B < 0$  e ciò significa che a sinistra si sono accumulati gli elettroni, cioè cariche negativamente.

La differenza di potenziale  $\Delta V$  genera un campo elettrico  $E = \frac{\Delta V}{r}$ , dove  $r$  è la larghezza del conduttore. Se questo è perpendicolare al campo magnetico  $B$ . In condizioni di equilibrio si ha per la [7.22]  $E = -v B$ , dove  $v$  è la velocità di deriva che abbiamo calcolato al par. 3.4. Dette:

$s$  la sezione del conduttore;

$l$  la sua lunghezza e quindi  $V = s l$  il suo volume;

$n$  la densità degli elettroni di conduzione, da cui  $n^\circ$  elettroni presenti =  $n V$ ;

si ha:

$$I = \frac{q}{\Delta t} = \frac{-e n V}{\Delta t} = -e n \frac{s l}{\Delta t} = -e n s v_{\text{deriva}}$$

$$\Delta V = E r = -v B r = \frac{I}{n e s} B r \Rightarrow \Delta V = \frac{r}{n e s} I B$$

A parità di corrente, di campo magnetico applicato e di dimensioni del conduttore:

- la differenza di potenziale che si stabilisce è inversamente proporzionale alla densità  $n$  degli elettroni di conduzione.

Nei metalli questa è molto alta e pertanto l'effetto Hall è molto debole, mentre nei semiconduttori, nei quali la densità dei portatori di carica è bassa, l'effetto Hall è abbastanza intenso e può essere utilizzato, con una corrente nota, per misurare l'intensità di un campo magnetico.

[Link utili](#)

[Università di Torino](#)

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Obiettivi conoscitivi

- *dato un moto rettilineo, saper riconoscere dal grafico spazio-tempo, velocità-tempo, accelerazione-tempo, un moto uniforme, uniformemente accelerato, armonico.*
- *Conoscere le relazioni che intercorrono tra velocità istantanea e grafico spazio-tempo, tra accelerazione istantanea e grafico velocità-tempo;*
- *conoscere la velocità dl suono in un mezzo aeriforme;*
- *Conoscere il principio di conservazione dell'energia, energia potenziale elastica, energia potenziale gravitazionale, energia cinetica;*
- *conoscere da cosa dipende il periodo di oscillazione di un oggetto appeso ad una molla.....va bene ve lo dico io  $T = 2\pi\sqrt{\frac{m}{k}}$*

[torna all'indice](#)