Seismograph System

EQ-1

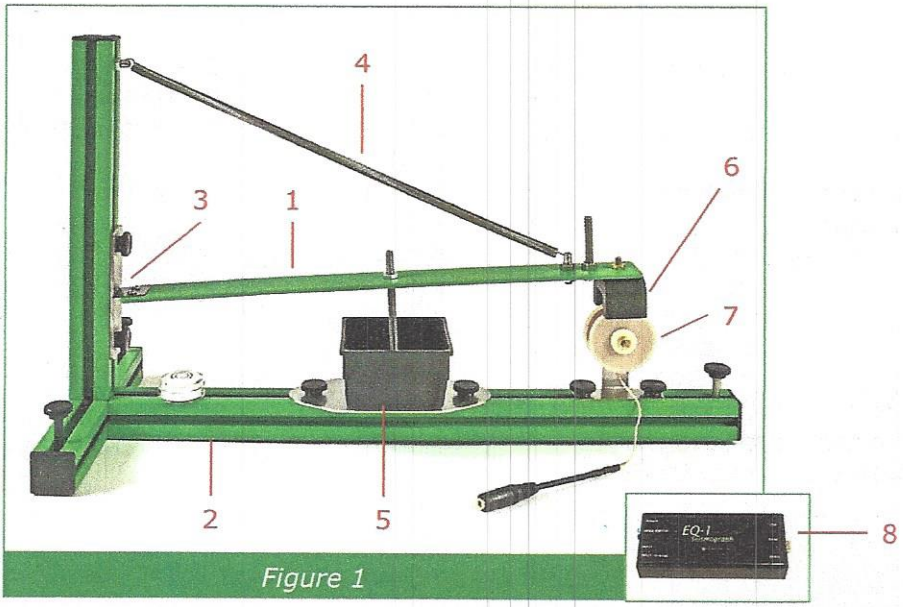


Figure 1

Description:

The EQ-1 Seismograph System consists of the seismometer unit, an interface box and associated cables, a computer running the Windows® operating system, and the *AmaSeis* software. It is designed for instructional use, both for demonstrating the operation of a seismometer in "student mode" and for continuously monitoring seismic activity in "earthquake mode."

The seismometer unit is a simple but sensitive device for detecting the vertical components of seismic waves generated by earthquakes and other events. It consists essentially of a horizontal beam (1) mounted on a stand (2). The beam has a knife-edge fulcrum (3) at one end and a supporting spring (4), allowing slow vertical oscillations which are damped by a vane in an oil-filled pan (5). A magnet (6) at one end of the beam induces a small voltage in a coil (7) when the beam oscillates with respect to the stand as a result of the transmission of external vibrations to the stand. This small voltage signal is amplified and digitized in a remote interface box (8), and is then passed by USB cable to a computer for continuous monitoring and analysis by the *AmaSeis* software. The EQ-1 is designed to allow easy setup and adjustment, and requires little maintenance in operation.

Seismograph System

Specifications:

Oscillating beam:	length: 39.5 cm mass: 400g (approx.) distance of C. of G. from fulcrum: 29.7 cm (approx.)
Overall dimensions:	50cm x 20.5cm x 31.5cm
Weight:	1.75 kg
Damping oil:	50:50 mixture of 10W40 motor oil and STP oil treatment. Approx. 150ml needed
Natural oscillation period:	1.53 s (approx.)
Earthquake detection sensitivity:	= magnitude 3.5 within 150km = magnitude 6.5 worldwide
Power requirement:	110VAC/60Hz, 2W
Computer requirement:	1GHz processor/512MB RAM/30GB hard drive gives good results Windows® 2000 or XP

Introduction:

The arrangement of the system is shown in *Figure 2*. The seismometer unit is placed in a suitable location (see below) and connected to the interface box by a long shielded cable. Because the signals generated by the seismometer unit are very small, this cable should not be too long. A 7m cable is supplied. The interface box is connected to the computer by a USB or serial cable. A USB cable is supplied. The included *AmaSeis* software can run in the background, so a computer dedicated to seismic monitoring can be used for other purposes simultaneously, but should never be turned off or allowed to hibernate.

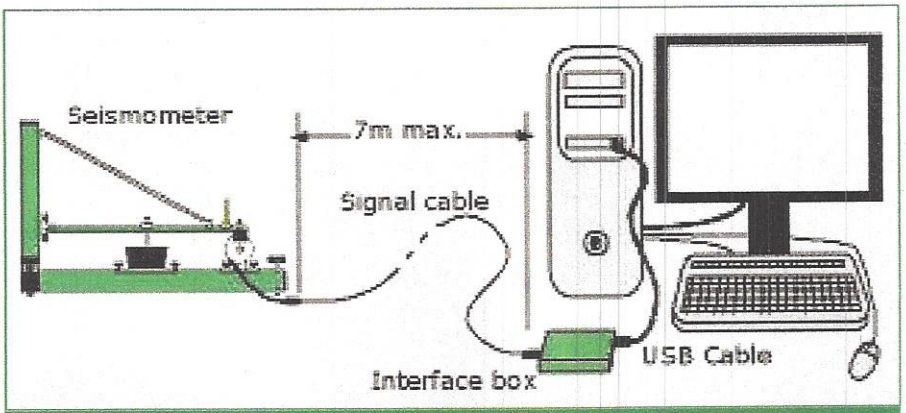


Figure 2

Choosing a Location

The EQ-1 seismometer is a sensitive instrument for detecting vibrations. In order to detect earthquakes, it should be placed in a location as free as possible from locally-generated "seismic noise" caused by people or machinery, which can hide small earthquake signals. Unwanted vibration sources include air conditioning units, nearby foot traffic, vehicle traffic, construction and weather. The ideal location for the seismometer is on a concrete or stone floor in a back room or out-of-the-way storage closet. The seismometer will operate in a public place where students can see it, but more local noise and fewer earthquakes will be detected.

Unpacking and Assembly:

Unpack the seismograph and check the parts you have received:

1 Beam with magnet, knife edge (CARE—SHARP!) damping vane, spring fitting & threaded rod
1 Base with coil, leveling screw & oil pan plate
1 Base crosspiece with 1 leveling screw
1 Leveling screw (separate)
1 End cap
1 Upright with fulcrum plate & spring fitting
1 Spring
1 Damping oil pan
1 Bubble level
6 Small washers
1 Hex wrench (3/16")
1 Interface box
1 Power supply (110VAC)
1 Signal cable - shielded stereo cable, 25 ft
1 USB cable
1 CD with *AmaSeis* software & drivers
1 Operating Instructions (this booklet)

ASSEMBLING THE SEISMOMETER

Figure 3 shows the parts of the seismometer.

Assemble the seismometer using the following steps:

Step 1:

Fit the base crossbar to the base by sliding the crossbar slot onto the socket head screw on the end of the base. Center the crossbar and tighten the screw through the hole in the crossbar, using the supplied hex wrench. Make sure the base and crossbar are aligned squarely to each other.

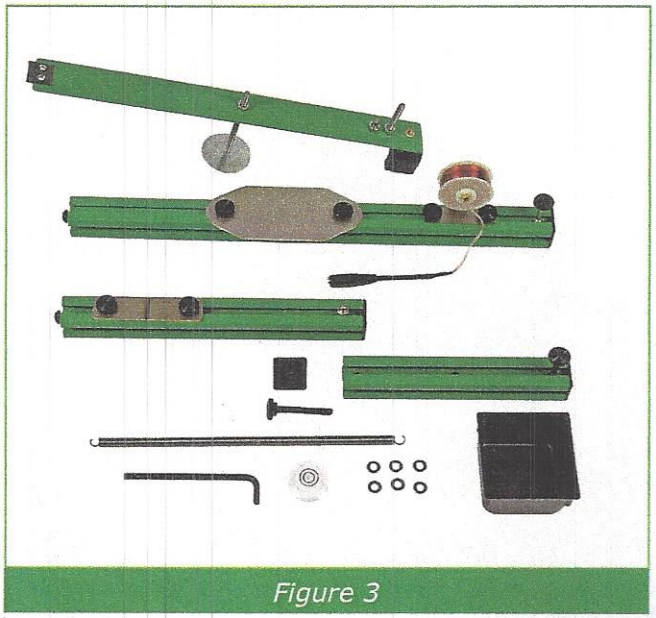
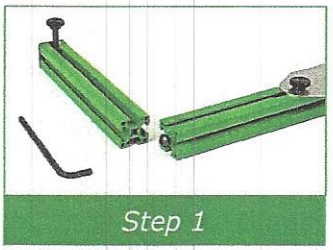
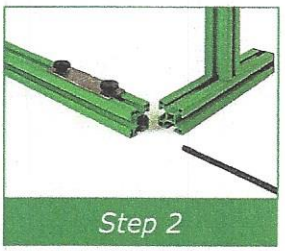


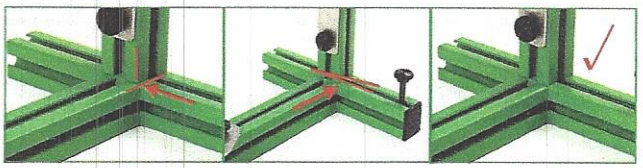
Figure 3

Step 2:

Fit the upright to the base by sliding the socket head screw on the lower end of the upright into the slot on the top of the crossbar. The fulcrum plate should face the base. Carefully center the upright on the crossbar and tighten the screw through the hole in the crossbar, using the supplied hex wrench. Make sure the upright lines up with the base and is square to it (*see pictures*). A careful alignment at this stage makes the adjustment of the beam much easier.


Step 1


Step 2

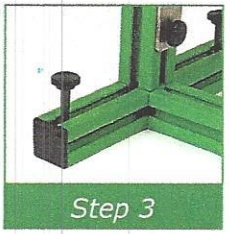

Wrong—out of **Wrong**—twisted **OK**

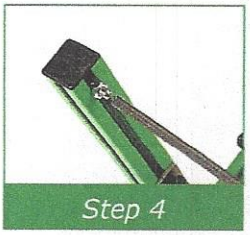
Step 3:

Fit the remaining leveling screw into the crossbar and attach the end cap onto the open end of the crossbar.

Step 4:

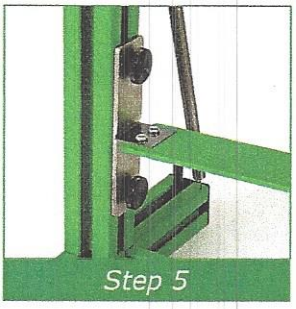
Hook the loop at one end of the spring into the hole in the spring fitting at the upper end of the upright.

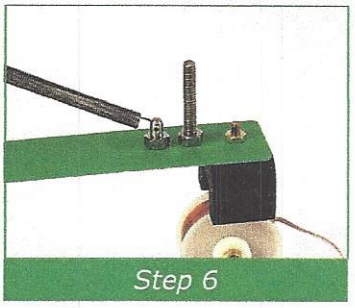

Step 3


Step 4

Step 5:

Hold the beam horizontally in your right hand and carefully line up the knife edge (pivot) with the horizontal slit in the fulcrum plate and seat the knife edge against the plate.

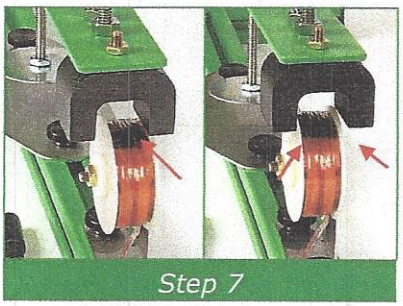

Step 5


Step 6

Step 6:

Still holding the beam horizontally in place with your right hand, use your left hand to hook the loop on the free end of the spring into the hole in the spring fitting on the upper side of the beam. Gently release the beam and allow it to swing freely.

Wrong *—catches coil* ***OK*** *—clears coil*

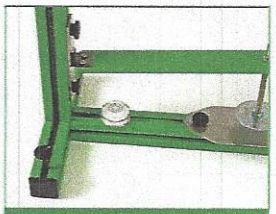

Step 7

Step 7:

View the magnet and coil from the end and check that the magnet is centered around the coil and can swing freely without catching on the coil on either side. If adjustment is necessary, first make sure that the knife edge is centered in the fulcrum plate groove, then carefully adjust the angle of the knife edge on the beam using the two Phillips screws securing the knife edge.

Step 8:

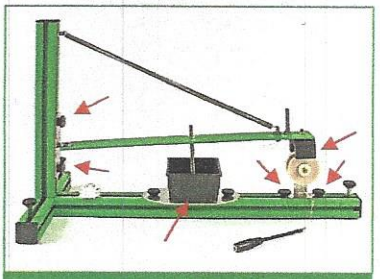
Place the seismometer in the location where it is to be used (see "Choosing a Location" above) then place the bubble level on the base and level the base using the three leveling screws.



Step 8

Step 9:

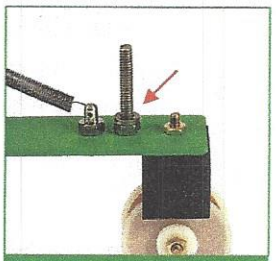
Carefully raise the beam and place the damping oil pan on its support plate. Lower the beam again and check that the damping vane does not strike the bottom of the oil pan during oscillations. Fill the pan half full of damping oil (50:50 mixture of 10W40 motor oil and STP oil treatment). Also place a drop of the oil on the fulcrum to reduce friction.



Steps 9 & 10a

Step *10*:

Adjust the position of the coil on the base so that it is centered beneath the magnet (two thumbscrews, *Step 10a*). Then adjust the angle of the beam so that during small oscillations of the beam, the magnet intercepts the windings packet of the coil at all times without hitting the coil support. The beam should be horizontal after this adjustment. The course adjustment is made by moving the fulcrum plate up or down (two thumbscrews, *Step 10a*). Fine adjustment is made by adding 1—6 washers to the vertical threaded rod near the end of the beam (*Step 10b*). It may also be necessary to make an adjustment in the height of the oil pan vane so that it doesn't hit the bottom of the oil pan and the beam balances correctly.



Step 10b

The seismometer is now ready for attaching the signal cable and interface box and installing the software.

Installation:

The seismograph system is delivered with a 25 ft shielded stereo signal cable that connects between the seismometer and the interface box and a 6 ft USB cable to connect the interface box to the computer. In choosing the location for the computer, bear in mind that a 110VAC power outlet will be needed nearby to connect the wall mount power supply for the interface box and that the interface box should be positioned in easy reach of the computer to facilitate electrical adjustments.

INSTALLING THE *AMASEIS* SOFTWARE

Install the *AmaSeis* software before connecting the seismometer and interface box to the computer.

- To use the *AmaSeis* software, your computer needs to be running Windows® 2000 or later.
- First close out of any Windows® programs that the computer is running and temporarily disable any virus protection programs to prevent conflicts during installation.
- Insert the CD into a CD drive and open the CD directory at *My Computer/EQ-1* if the directory does not open on its own after the CD boots up.

- First install the USB driver (skip this step if you are using a serial port connection.) Select and run the *CDM_Setup.exe* program.
- Now select and run the *AmaSeis_Setup.exe* program. Follow the on-screen instructions of the installer. The software and drivers will be installed onto your hard drive. Remove the CD from its drive when installation is complete.
- Run the *as1.exe* program either from the desktop "*AmaSeis*" icon or from the *AmaSeis* folder on your hard drive. Since you have not yet connected the seismometer, you will receive two error messages saying there is a problem with 'COM1' and no device has been found. Click 'OK' to these and wait until the main "Helicorder" screen comes up. Under the *Settings* menu select *Device* then *EQ1*, then click *OK*. Close out of the *AmaSeis* program and restart it for your selections to take effect. The software will still not recognize the (unconnected) seismometer. You will make further adjustments to correct this later.

CONNECTING THE SEISMOMETER TO THE COMPUTER

- The 25 ft. signal cable has a 3.5 mm male connector at each end. Plug one end into the socket attached to the seismometer coil.
- It is essential to cover the seismometer with a protective cover to eliminate disturbances due to drafts and to prevent dust settling into the damping oil. A suitable protective cover is available separately, or an inverted aquarium or plastic tub works very well.
- Run the cable to the computer, routing it where it will not be a hazard to foot traffic.
- Plug the interface box power supply into a nearby wall outlet then plug the end of the power cable into the socket on the left end of the interface box.
- Plug the free end of the signal cable into the socket on the left end of the interface box.
- Plug the USB cable into the socket on the right end of the interface box, and plug the other end into a free USB connector on your computer. (If your computer does not have a USB port, you can use a serial cable instead—see the box below).

Don't have a USB port on your computer?

Some older computers do not have USB ports. These computers will have a serial port. You can use a serial port with the EQ-1 instead of a USB port. The interface box is provided with a serial connector (DB9 female) to allow this. You will need to obtain a 6 ft. serial cable with a DB9 male connector on one end and a connector to fit the serial port of your computer on the other end. The serial port on many computers is designated COM1.

The Interface Box:

Figures 3-5 show the EQ-1 interface box.

The interface box contains a well-shielded low frequency amplifier that accepts the analog signal generated by the magnet and coil of the seismograph. The amplified output is digitized at a fixed sample rate for transmission to the computer by a USB or serial cable.
The inputs and controls for the interface box are located on the ends of the unit.

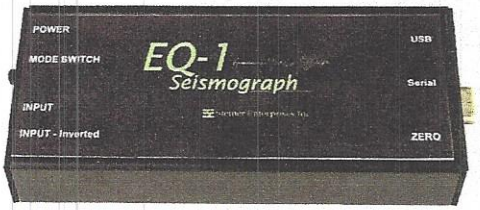


Figure 3

Figure 4 shows a schematic of the left end of the box, which contains the power supply socket (1), the mode switch (2) and two 3.5 mm stereo sockets for the signal input from the seismometer. The signal can be input as received (3) or sent through an inverting input (4). The inputs are identical except they show opposite polarity signals on the software screen.

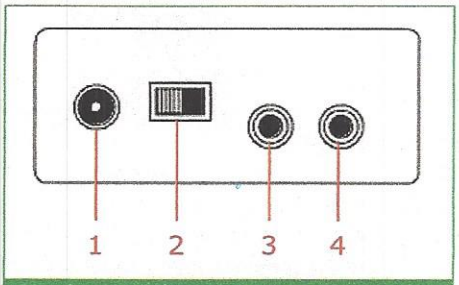


Figure 4—Left End

The position of the mode switch (2) controls the sample rate of the interface box. With the switch in the left position, the sample rate is approximately 10 /sec, which is suitable for earthquake monitoring. The right position of the switch sets the sample rate to approximately 50 /sec for classroom demonstrations. The frequencies of the vibrations generated in the classroom by foot traffic, dropping heavy objects, or other test disturbances are higher than typical earthquake frequencies, and the higher sample rate gives better definition of the waveforms. Recording earthquake data at this higher sample rate is unnecessary and would just take up more storage space.

Figure 5 shows a schematic of the right end of the box. This contains the zero adjustment potentiometer (1), the serial connector (2) and the USB connector (3).

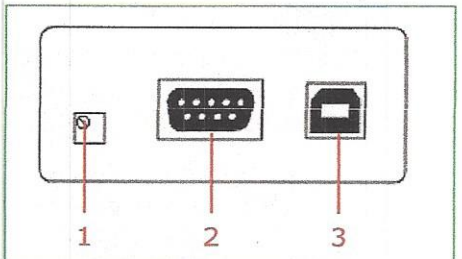


Figure 5—Right End

The zero adjustment potentiometer is used to set the digital output level as close to zero as possible when the instrument is quiescent (i.e. not detecting an earthquake or other disturbance.)

The *AmaSeis* Software:

The *AmaSeis* software was written by Alan Jones of SUNY Binghamton and forms part of the IRIS materials. News and downloadable updates are available at his website. A link is given in the "Resources" section below.

BRIEF DESCRIPTION

The software accepts digitized vibration data from the interface box and displays it continuously on the computer screen in the format of a traditional helicorder. Each line on the screen represents one hour of data, and the entire screen displays a 24-hour period. The data is labeled with the date on the line representing 12:00—1:00 a.m. UTC (numerically the same as GMT). Each line is labeled on the left side with the time the hour begins, measured in UTC . *Figure 6* shows the main helicorder screen, which appears on startup after the introductory splash screen.

The current hour is the lowest line on the screen; data for the previous 23 hours appear above the current hour and the screen scrolls one line at the beginning of each new hour. Data that scrolls off the top of the screen is not lost; all data is saved for a user-defined period of days. The software also allows the user to set the parameters describing the seismometer and controlling the data processing as well as to apply filters to help identify earthquake signals, extract and examine these signals, and determine the distance of the event from the seismometer. There are extensive *Help* screens associated with the main screens and function dialog boxes in the software, and most of the detail information needed to work with the software can be obtained from these *Help* screens. An extensive tutorial for using the AmaSeis software is available online at the URL given in the "Resources" section. Note that these tutorials refer only to "AS1" as the seismometer model designation. All the comments apply also to the EQ-1 model.

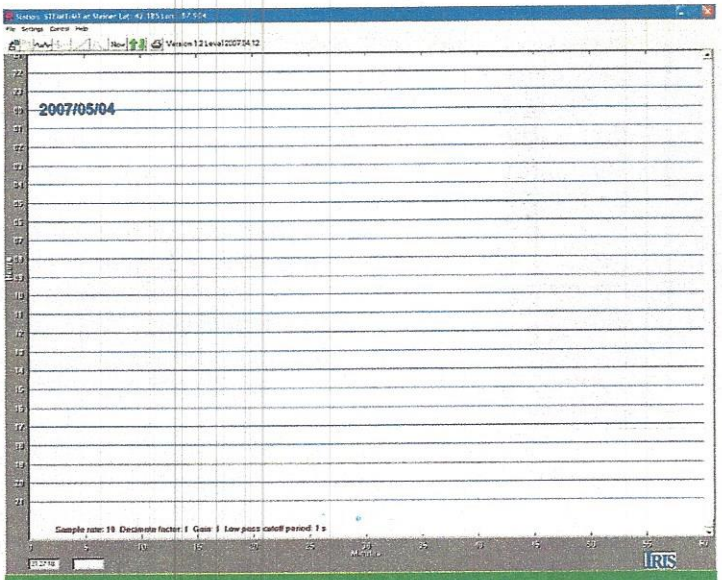


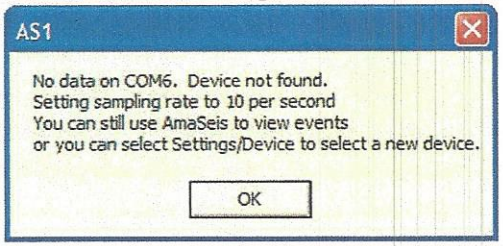
Figure 6

Operating the Seismograph:

FIRST TIME OPERATION

After installing the hardware and software as described above, a few adjustments are needed before monitoring for seismic activity or demonstrating in the classroom.

- On booting the *AmaSeis* software, you may get an error message "Problem opening COM1." This is because the software is not looking for the interface on the right COM port and needs to be reset. This will usually be the case when using a USB connection. Click "OK" and allow the software to finish booting. You will then see the following pop-up:



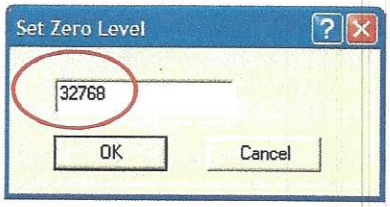
Click "OK" again, and the helicorder screen will come up.

- To set the correct COM port, first exit the *AmaSeis* software.

  For a USB connection, the computer's operation system will have assigned a virtual COM port to the seismometer when you connect it to the computer. You can discover this value after you have connected the seismometer to the computer by checking the listings in the Windows® *Device Manager* display.

  For a serial connection the COM port to which the EQ-1 is connected can also be found at the Device Manager.
  Open the Device Manager at: *Control Panel/System/Hardware/Device Manager*. The seismometer will appear as a serial device. Note the number assigned to the EQ-1, close the Device Manager, and restart the *AmaSeis* software. On the *Settings* menu, open the *COM port* window, enter the Com port number and click "OK".
  After setting the COM port value, restart the *AmaSeis* software and you should see data appearing on the bottom line of the helicorder window (you may also need to reboot your computer if this does not happen)

- Set the zero level. The digital value that corresponds to a zero signal level is "32768."
  On the *Settings* menu select *set zero level...* A pop-up window appears:
  Enter "32768" into the data value window and click "OK." You will not need to enter this

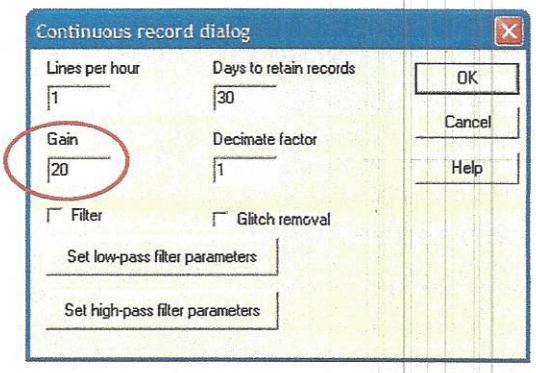


  value again.

- Allow the seismometer undisturbed time to settle down so that no signal is being transmitted to the interface box. On the *Settings* menu of the *AmaSeis* software, select the *Show data values* option. A pop-up window appears:
  The *Level* window will contain a rapidly changing number, representing the digital data

  being sent from the interface box. Since there is no real signal from the seismometer, this represents electronic noise from the amplifier plus any zero offset. Using a small screwdriver, carefully adjust the zero potentiometer on the right end of the interface box to minimize the values shown to just electronic noise. You should be able to obtain values varying between –50 and +50 or better. The amplifier is very stable, and you should not need to repeat this adjustment again.

- You can adjust the vertical size of the displayed trace by changing the gain value on the *Settings/Helicorder* menu. A dialog box labeled "*Continuous record dialog*" appears. Entering a value into the Gain box scales the display of the signal. For the EQ-1, a value of 1 or 2 is usually sufficient.



SEISMIC MONITORING MODE

- Make sure the mode switch on the left end of the interface box is in the left position to set the sample rate to 10 /sec. You will need to restart *AmaSeis* if you change the position of the switch.
- *AmaSeis* can run in the background, allowing you to use the computer for other activities while monitoring for seismic activity. You can keep screen saver software active, but be sure to disable any hibernation or automatic power-down options, as these will interrupt recording.

CLASSROOM DEMONSTRATION MODE

- Set the mode switch on the left end of the interface box to the right to set the sample rate to approximately 50 /sec
- You may wish to increase the gain setting to obtain a larger display in the helicorder mode.
- In this mode, the seismograph will detect vibrations in the building caused by students walking nearby, dropping books, etc.

Seismograph System

Resources

Website for *AmaSeis* use instructions:

http://web.ics.purdue.edu/~braile/edumod/as1lessons/UsingAmaSeis/UsingAmaSeis.htm

Website with information on interpreting seismograms:

http://web.ics.purdue.edu/~braile/edumod/as1lessons/InterpSeis/InterpSeis.htm

Website for software news and upgrades:

http://bingweb.binghamton.edu/~ajones/AmaSeis.html

Website with lots of seismology information:

http://web.ics.purdue.edu/~braile/

Maintenance:

It is essential to protect the seismograph in use with a draft and dust shield as mentioned in the installation procedure. If this precaution is taken, no special maintenance is necessary.

Storage:

If the seismograph will not be used for some time, carefully remove the beam and spring and empty and clean the damping oil pan. Store the unit in a dry place and protect it from dust.